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Inaugural of the New York Extension of the Pennsylvania Railroad: Opening of the Passenger Station.

The past week saw the first public use of the Pennsylvania Railroad's prodigious undertaking to extend its tracks across the Hudson River into New York City and thence across the East River to a connection with its Long Island system (Long Island R. R.). On Sept. 8, 1910, trains of the Long Island R. R. began operating through the East River Tunnels to the new station; Pennsylvania traffic through the Hudson River Tunnels will begin in the near future, it is expected.

The great works comprised in this undertaking are not only of exceptional magnitude—the cost was over a hundred million dollars—but in part presented constructional difficulties that made the whole project appear problematic. Chief among the elements of difficulty was the problem of the river tunnels—two tubes under the Hudson, four under the East River, the two groups presenting radically different soil conditions—and their successful construction is an engineering achievement of first rank. The crosstown tunnels, two double-track tunnels in rock, also proved to be very anxious tasks. And the Terminal Station work, with its large volume of excavation and extensive building operations, in a crowded district, was subject to such hampering conditions as to make it a management problem of high order. The engineer therefore

FIG. 1. THE NEW TERMINAL STATION OF THE PENNSYLVANIA R. R. IN NEW YORK CITY.
(View looking southwesterly, Seventh Ave. front at left, 33d St. side at right.)

has peculiar interest in the undertaking and in the fact that now, after but eight years of labor, it is complete for use.

Fortunately a comprehensive record of the constructional operations has been made public, by a series of some fifteen elaborate monographs* published in "Transactions of the American Society of Civil Engineers." The seeker after information will therefore have at his disposal, when the series shall be complete, a 1,000-page treatise on the work from the Harrison junction station, in New Jersey, to Sunnyside Yard, on Long Island, including explicit statement of difficulties, methods of solving them, and numerous unit costs, all amply illustrated with drawings and views, and fully authoritative. We may therefore confine ourselves here to a brief categorical summary of the main parts of the enterprise.

Origin.

The Hudson River is crossed by only one railway line in the 150 miles below Albany: the Central New England, at Poughkeepsie Bridge. The railways which cross New Jersey to terminals at New York Harbor have from time immemorial stopped at the Hudson and distributed their traffic thence by lighters, car-ferries and passenger-ferry lines. The river here is over 3,000 ft. wide at its narrowest place, and its depth, the soft bottom and the busy shipping argue convincingly against channel piers for a bridge. A bridge of span 3,000 ft. or more, or a tunnel line, are alone possible.

Many engineers will recall some at least of the repeated projects, in the 80's and 90's, for bridging the Hudson at New York by a colossal suspension structure. They will also remember the early beginning and long-drawn history of the old Hudson River tunnel (Haskin's scheme),† an enterprise originally planned for railway transfer, though now completed on a modified scale for passenger rapid-transit only. The various bridge and tunnel schemes (Haskin's was not the only Hudson tunnel project conceived, though the only one actually started) arose mainly from the conviction that the New Jersey terminals ought to be transferred into New York, so that ferriage would be avoided. The Pennsylvania Railroad was interested in many of these projects.

Gen. Raymond's paper (above noted) expresses the view of the responsible railway officials clearly in its opening paragraph:

> Some time before the appointment of the Board of Engineers, which supervised the designing and construction of the New York Tunnel Extension of the Pennsylvania R. R., the late A. J. Cassatt, then President of the company, said to the writer that for many years he had been unable to reconcile himself to the idea that a railroad system like the Pennsylvania should be prevented from entering the most important and populous city in the country by a river less than one mile wide.

Similar thoughts, no doubt, existed in the minds of the officials of other New Jersey trunk lines for many years. But in the case of the Pennsylvania it had gone much beyond the stage of mere thoughts, and the year 1901 was only the closing term of a long period of scheming for a New York entrance. Mr. C. M. Jacobs says in his paper on the North River Division (noted above), that,

> since shortly after the year 1871, when the Pennsylvania Railroad system was extended to New York Harbor through the lease of the New Jersey lines, the officers of that company have been desirous of reaching New York City by direct rail connection.

Independently, the Long Island R. R. long worked on the problem of crossing from Long Island to Manhattan. When therefore, in 1900, the Pennsylvania acquired a controlling interest in the Long Island R. R., the two movements became united, and in the hands of Mr. A. J. Cassatt, President of the Pennsylvania R. R. their combined momentum was speedily utilized to create the actual scheme carried through.

Mr. Jacobs' paper, it fortunately happens, gives an excellent summary of the many projects on both railways, as far back as 1890, a number of which are recorded for the first time. The projects include a Long Island R. R. tunnel from Brooklyn to East and North Rivers to Communipaw

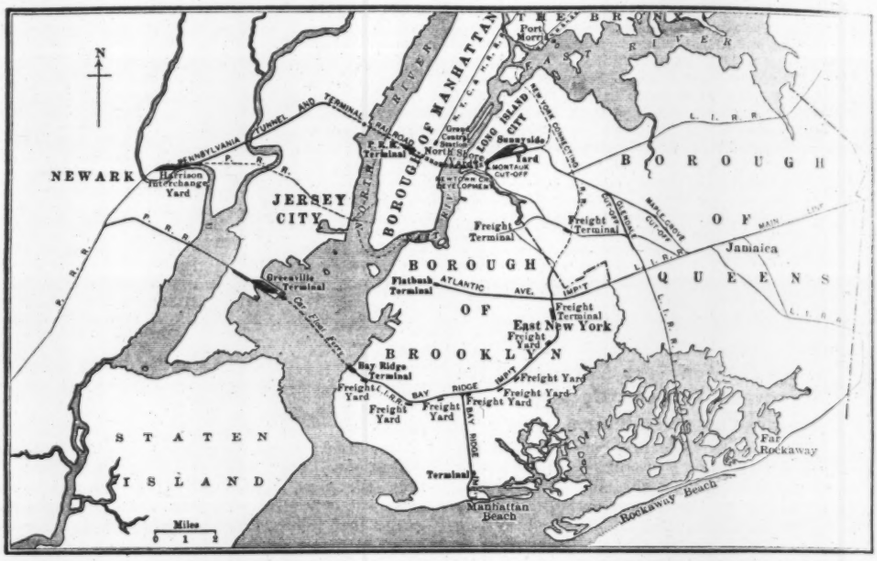

FIG. 2. SKETCH MAP OF NEW YORK CITY AND VICINITY, SHOWING THE PENNSYLVANIA R. R. NEW YORK EXTENSION AND ASSOCIATED IMPROVEMENTS.

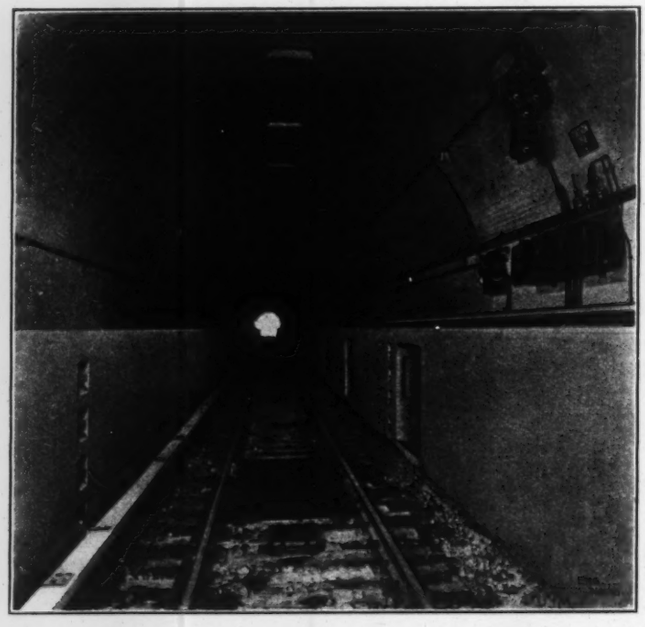

FIG. 3. VIEW IN ONE OF THE TUNNELS OF THE NEW YORK EXTENSION.

(Looking west in North tube of Hudson River tunnels, from point under Weehawken bulkhead toward Weehawken Shaft. The side benches, 11 ft. 8 ins. apart in the clear, are expected to be an important protection against serious accident by derailment. Their top surface forms a walking platform. The electric ducts are embedded in the benches.)

a series of rapid transit tunnels from the Pennsylvania station to lower New York (1891); a southern belt line from near Rahway across Staten Island, under the Narrows, around Brooklyn, and across the East River by bridge to a station at 38th St. and Park Ave. (1891); a North River Bridge entrance for the Pennsylvania, with a 14-track bridge of 3,100-ft. channel span at 23d St., basing on an 1888 Federal charter (1892-1900); a Long Island-Pennsylvania tunnel route from Jersey City to Cortlandt St. and along under Maiden Lane by East River tunnel to Pineapple St. (Brooklyn) and under Fulton St. to a station at Flatbush and Atlantic Aves. (1892-93); an East River tunnel at 34th St. for handling baggage and express from the Long Island R. R. (1893); a four-track bridge over the East River at Blackwell's Island; a subway line of the Long Island along Atlantic Ave., Brooklyn, and a tunnel thence under the East River to Broadway and Cortlandt Sts., New York (1896), which scheme led to actual construction of the Atlantic Ave. subway and electric operation of the Long Island terminal lines; a tunnel for the Long Island at 33d St. under the East River, with a Manhattan terminal at Sixth Ave.; and an East River tunnel at 42d St. to connect the Long Island with the New York Central.

Many different movements and many men are represented in these several projects. Such undertakings as the Atlantic Avenue Improvement and the North River Bridge stand quite unrelated. Yet the general purpose was the same in all, namely to bring railway connections across the Hudson and East Rivers to Manhattan. Any decided and well-supported step in realization of some part of this purpose, obviously, was bound to entrain and unite several of the prior projects in one. And this is what came about when the Pennsylvania started work.

The twelve years from 1888 to 1901 brought some developments affecting this subject vitally, and the realization of a river-crossing must be regarded in a sense as their natural resultant. They were as follows:

(1) Constant progress in tunneling experience made the success of a tunnel ever less problematic. (2) Electric haulage gave an ideal solution for the problem of tunnel transportation. (3) The growth of population on both sides of the Hudson made the saving of wasted time in ferri-

*The first ten of these papers, covering 478 pages, are grouped in Vol. LXVIII. of "Transactions," September, 1910. They are:
C. W. Raymond: The New York Tunnel Extension of the Pennsylvania Railroad.
C. M. Jacobs: The North River Division.
Alfred Noble: The East River Division.
E. B. Temple: Meadows Division and Harrison Transfer Yard.
F. Lavis: The Bergen Hill Tunnels.
B. H. M. Hewett and W. L. Brown: The North River Tunnels.
B. F. Cresson, Jr.: The Terminal Station—West.
G. C. Clarke: The Site of the Terminal Station.
J. H. Brace and Francis Mason: The Cross-Town Tunnels.
J. H. Brace, Francis Mason and S. H. Woodward: The East River Tunnels.

†A summary of its history was given in our issue of Feb. 27, 1908, pp. 230-234.

more important; also the saving of minutes on long-haul traffic acquired a greater competitive value when the standard running time from New York to Chicago was reduced from 30 to 24 hours. (5) The acquisition of the Long Island Railroad

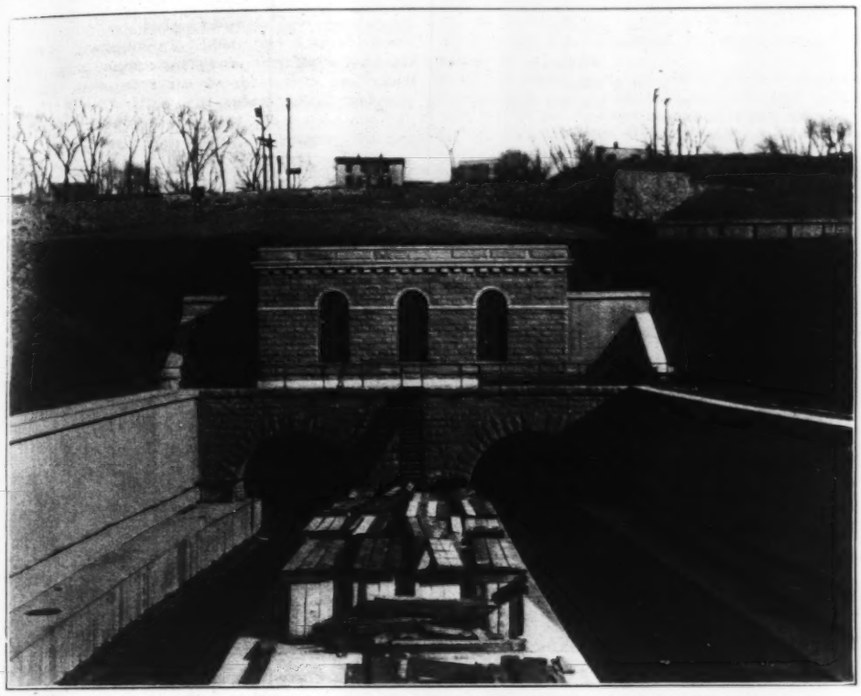

FIG. 4. "HACKENSACK PORTAL," THE WEST PORTAL OF THE BERGEN HILL TUNNELS.
(Here the New York Extension leaves the Meadows embankment and enters the tunnels on 1.3% down grade.)

by the Pennsylvania, in 1900, tripled the value of a Hudson River crossing by creating the further possibilities of a through line to Long Island and a rail connection by way of a bridge over Hell Gate with the New England system terminating in the upper part of New York City.

Mr. A. J. Cassatt is credited with the decision to take action under these circumstances, in spite of the enormous cost of a New York extension. In 1901 the opening of the electric terminal line of the Orleans railway in Paris induced him to develop a comprehensive tunnel scheme at once, after negotiations for a North River bridge to be used jointly with other railways had just come to failure. Mr. C. M. Jacobs and Mr. J. V. Davies advised him concerning the feasibility of river tunnels for heavy traffic, and before the end of the year the project had been developed substantially as it exists to-day. At the beginning of 1902 Mr. Cassatt appointed an able board of engineers* to report finally on practicability and to direct the designing and construction. The labors of this board progressed without delay to the establishment of a large engineering organization, the production of working plans, and the letting of contracts.

Associated Improvements.

The New York Extension from the New Jersey shore to New York and Long Island is self-contained. But its advantages are turned to much fuller account by several important auxiliary projects, which relate chiefly to the improvement of the Long Island lines and the production of an improved independent freight connection between the New Jersey and Brooklyn shores; in part they relate to the creation of rail connection between the Long Island and the Bronx mainland, which connection will form the final tie between the Pennsylvania lines and the New England trackage, for both freight and passenger service.

LONG ISLAND ELECTRIC TRACTION.—Electric traction was an essential of the Atlantic Avenue Improvement, as well as of the Pennsylvania-Long Island project. Thus an early start was made in developing the practical details of the equipment by fitting the terminal sections of the Long Island lines for third-rail motor-car operation. Service was begun in 1906, after about four years of construction. The equipment was described in our issue of Nov. 2, 1905. While this improvement stands by itself, and might have been undertaken without reference to the future New York connection, it is now in fact an element of the whole development.

GREENVILLE - BAY RIDGE FREIGHT FERRY.—Several miles south of its present Jersey City terminal, the Pennsylvania developed a large freight-ferry terminal, at Greenville, Bayonne City, and another terminal directly across New York Bay at Bay Ridge, Brooklyn. The latter being connected with the Long Island City terminal and the Sunnyside Yard through a belt line around Brooklyn, amplified by new freight collecting stations and yards, the freight problem of the Long Island system was solved in harmony with the passenger tunnel system.

ATLANTIC AVENUE SUBWAY.—This scheme of prior date involved the conversion of a surface line of the Long Island R. R. to an electrically-operated subway in the heart of Brooklyn. The improvement is about 5¼ miles long, including the subway and its elevated extension to East New York station.* The change was urgently demanded as a needed civic improvement in Brooklyn, to do away with the anachronism of a surface steam railway in the center of a city. Yet it could not be taken in hand advantageously until the electric equipment of the Long Island lines was planned. By affording a greatly enlarged terminal station at Atlantic and Flatbush Avenues, adjacent to the Brooklyn terminus of the Interborough rapid-transit subway, this improvement gives direct and adequate passenger facilities for Long Island points from lower Manhattan and Brooklyn.

When the Bronx connection across Hell Gate is built, it will be possible to carry New England passengers into central Brooklyn by Atlantic Ave. as well as into Manhattan by way of the

*Gen. C. W. Raymond and for a time Mr. Gustav Lindenthal, and the Chief Engineers of the several divisions noted later, namely Messrs. C. M. Jacobs, Alfred Noble, George Gibbs, and Wm. H. Brown.

*See Eng. News, May 22, 1902, p. 418, and Dec. 18, 1902, p. 518.

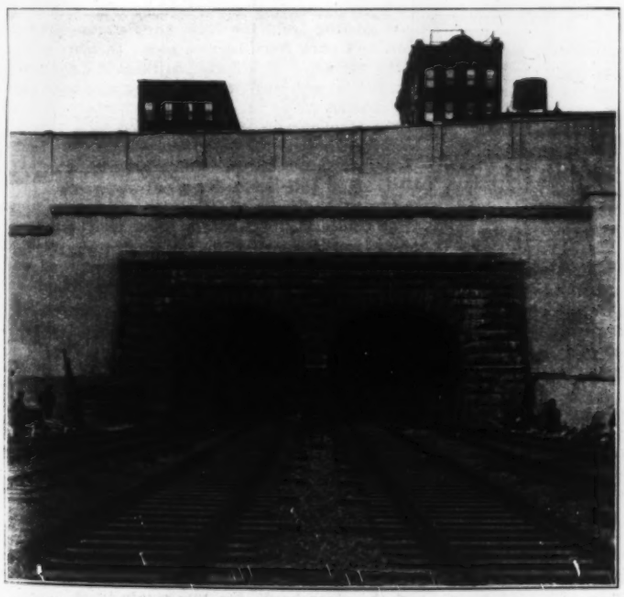

FIG. 5. EAST PORTAL OF THE HUDSON RIVER TUNNELS, AT THE TENTH AVENUE END OF THE TERMINAL STATION YARD.
(Looking west from the yard.)

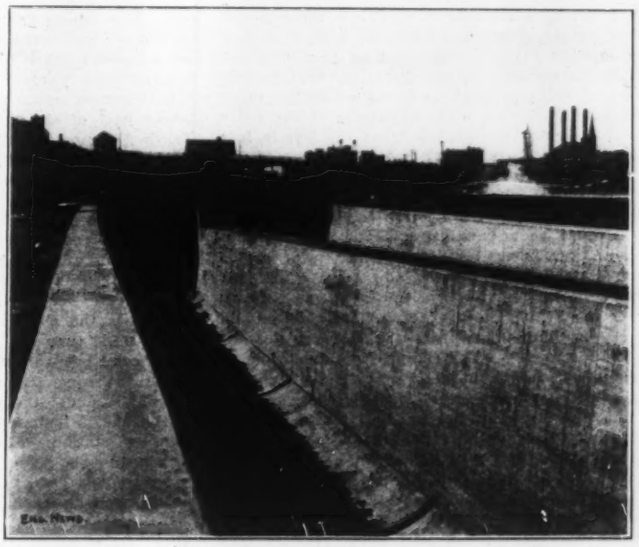

FIG. 6. LONG ISLAND PORTAL OF THE EASTBOUND TUNNELS ("B" AND "D"), AT WESTERLY END OF SUNNYSIDE YARD.
(View looking west down the approach cut. The two westbound tunnels have separate portals, both of which lie somewhat to the west of the B-D portal.)

East River tunnels to the new Pennsylvania station. Thus the possibility exists, under the entire system, of giving Brooklyn for the first time direct passenger service to west and north.

OTHER LONG ISLAND CHANGES.—A new cut-off line tying the Sunnyside Yard more directly into the Long Island Railroad network, the Glendale Cut-off, is important as increasing the efficiency of the new system. This is a new railway line about two miles long, located as may be seen in the map Fig. 2. Extensive yard, track, and station improvements at Jamaica and other points provide for the changed and increased traffic. Other track connections and new piers and docks at Newtown Creek carry out the development of the freight-carrying facilities of the system.

ELECTRIC SUBURBAN OPERATION TO NEWARK.—As the Pennsylvania's traffic to New York through the tunnels requires electric traction, it is necessary to change locomotives on all through trains at some interchange point. For this purpose the Electric Division is continued beyond the Hackensack Meadows tunnel portal across the meadows to the junction with the existing main line at Harrison, just east of Newark. The trackage to the present Jersey City terminal station will also be equipped for electric traction. At Harrison a large interchange station and yard has been built. Suburban trains, however, will operate electrically to Newark, a mile farther. Thus the railway will operate electrically between New York and Newark (for the present). The possibility of easily extending electric operation, for the suburban trains at least, over the whole length of the suburban zone, some twenty or thirty miles farther, is obvious, especially as the line is free of grade crossings on this whole distance.

AUXILIARY TUNNEL SERVICE TO LOWER NEW YORK.—The independent system of rapid-transit tunnels of the Hudson & Manhattan Ry. is utilized as an auxiliary to the Pennsylvania by an agreement for joint operation of rapid-transit trains through the downtown (Cortlandt and Fulton St.) tunnels of the former to Newark over the Pennsylvania tracks of the old terminal division. For this service the Hudson & Manhattan company is extending its tunnel line to reach the surface on the Pennsylvania right-of-way in the western part of Jersey City, and the Pennsylvania is equipping its tracks west to Newark to carry the rapid-transit trains. This arrangement will give an important supplement to the Pennsylvania's local passenger service, and will tend to advantageously relieve its trains of a large part of the Newark traffic headed toward the lower part of New York City.

HELL GATE CROSSING.—This final element of the broad scheme has not yet been started. It comprises a line from the Long Island tracks to the East River in the northern part of Long Island City, a great arch bridge (span 1,000 ft.) and other bridge and viaduct construction to Ward's and Randall's Islands in the East River and thence to Port Morris, in the northerly part of New York City, and a connection here with the New York, New Haven & Hartford R. R. This undertaking is known as the New York Connecting R. R. It will eliminate a large amount of freight and passenger ferriage from Jersey City and Long Island to Port Morris and will save many hours on through traffic passing beyond New York City.

FIG. 7. SUNNYSIDE YARD SEEN FROM QUEENSBORO BRIDGE APPROACH VIADUCT, LOOKING EASTERLY.

(South yard left of center. Two westbound tunnel tracks in left foreground, four tracks to Long Island City station in middle. Location of eastbound tunnel tracks at extreme right, line "D" crossing over beginning of loop tracks.)

Principal Constructive Parts of the New York Tunnel & Terminal R. R.

What was above called the New York Extension proper exists in the corporate form of the New York Tunnel & Terminal R. R. It embraces the following:

1. Hackensack Meadows crossing, a double-track railway traversing the marshes of the Hackensack River northeasterly, on embankment, from the main line at Harrison to the west portal of the Bergen Hill tunnels, 6.04 miles.

2. Bergen Hill tunnels, two single-track rock tunnels about 6,000 ft. long, running easterly from the west face of Bergen Hill to near the west bank of the Hudson, on a 1.3% descending grade to form the approach to the river tunnels.

3. North River tunnels, two single-track shield-driven subaqueous tunnels under the Hudson River, about 6,000 ft. long between shield-chambers, continuing as a single rock and earth tunnel about 1,000 ft. farther east to the Terminal Station yards.

4. Terminal station and yards, covering the larger part of six blocks, between Seventh and Tenth Avenues (abt. 2,500 ft.) and 31st and 33d Sts. (abt. 450 ft.). The station building covers the blocks Seventh to Eighth Aves., 31st to 33d Sts.

5. Crosstown tunnels, two double-track rock tunnels extending easterly from the Terminal Station, one under 32d St. and one under 33d St., about 5,700 ft. to shafts on the west bank of the East River. They swing somewhat northerly as they near the shafts and divide each into two single-track tunnels.

6. East River tunnels, four single-track shield-driven subaqueous tunnels, crossing somewhat diagonally under the East River, about 3,900 ft., to two shafts just west of the Long Island R. R. terminal station; thence rising as four shield-driven tunnels about 2,000 ft. and as cut-and-cover tunnels 1,000 to 2,000 ft. farther to portals opening on the trackage of Sunnyside yard.

7. Sunnyside Yard, a storage and terminal yard about 1½ miles long by ½ mile wide, occupying an undeveloped area a mile east of the river, in Long Island City.

The total length of line, from Harrison Yard to Woodside Ave. (the east end of Sunnyside Yard), is 13.66 miles, of which about half is in tunnel.

Meadows Division.

The interchange yard at Harrison contains two platforms 1,100 ft. long and 28 ft. wide, 2 ft. 10 ins. above top of rail, served by four tracks alongside and two middle running and shifting tracks. Platforms and longitudinal supporting walls are of reinforced concrete, with wooden pile foundation under the walls; the platforms are surfaced with paving brick between walls, and with granolithic finish and a steel edge on the 20-in. overhang. Two-column umbrella sheds draining inward from the edges and with ventilating skylight along the middle cover with platforms.

These platforms lie along the present New York Division passenger tracks. A loop track at the west end serves to turn locomotives. Storage tracks for locomotives adjoin to the south. The tracks at the east rise on 0.5% gradient and cross the New York Division and the Delaware, Lackawanna & Western tracks on viaduct, thence continuing on embankment, at a height of 25 to 30 ft. above the surface of the meadows, northeasterly to the west approach cut of the Bergen Hill tunnels.

The embankment was made largely with rock, part coming from the New York station excavation and part from borrow pits. In spite of the soft marsh soil, little settlement appeared, though lateral flow of the ground appeared in a few places.

The Hackensack River is crossed by a through swing-span 300 ft. long and six 110-ft. plate-girder approach spans. There are also a number of bridges over roads and railways, using generally half-through plate-girder spans with solid floor consisting of I-beams filled solid with concrete and covered with felt and waterproofing compound protected by a pavement of sand and grouted brick for carrying the stone ballast.

The line was under the Chief Engineer of the Pennsylvania R. R., Mr. Wm. H. Brown to 1906, and Mr. A. C. Shand since then, with Mr. F. B. Temple as Assistant Chief Engineer. Mr. W. C. Bowles was Engineer of Construction. The contractors were Henry Steers Inc., and H. S. Kerbaugh, Inc., for the embankment; Henry Steers Inc., for tracklaying; McMullen & McDermott, and Drake & Stratton Co., for bridge substructures; and Pennsylvania Steel Co. for bridge superstructure.

Bergen Hill Tunnels.

These tunnels, on 1.3% down grade from the west face of Bergen Hill to a large permanent shaft on the river bank, are two single-track tunnels, 5,920 ft. long, 37 ft. apart on centers, with clear dimensions 19 ft. by 18 ft. 4 ins. high to inside of arch, a semicircular roof arch of 9 ft. 6 ins.

dius, and a 22-in. lining of concrete. Along ch side is built a concrete bench 7 ft. 8 ins. gh (5 ft. 6 ins. above top of rail) leaving a ntral width of 11 ft. 8 ins. These benches rm a feature of all the tunnels, and were sug- ested by President A. J. Cassatt as an import- t safeguard in case of derailment. The wiring cts are embedded in them.

The rock penetrated is diabase, the trap dike rming the hill, which dips 17° 40′ to the north- st (the tunnels are alined N. 50° 30′ W.); at e east end a 400-ft. zone of faulting followed 60 ft. of compact sandstone was met. The p generally was exceedingly hard to drill, so t the average rate of drilling in the hardest rtions was only 1 ft. per hr.

While the east end is 64 ft. below M. H. W., ater gave no trouble. However, timbering was quired at many points because of the jointed ructure of the rock, and especially in the east- n fault zone.

The top center heading method of attack was ed exclusively, the heading enlargement work ing kept back close to the bench excavation. Work was conducted from both portals and from central shaft 212 ft. deep. Mucking was done largely by steam-shovel running on a standard-gage track and loading small 1-yd. cars operated on tracks of 3-ft. gage. At the east end all muck had to be hoisted out of the shaft and carried away by rail, but at the west end the muck cars were run directly out along the Meadows line and dumped to form the embankment.

Ventilation was required for a time in the east end. The cross-passages which were broken out between the two tunnels at short intervals were closed by bulkheads and a fan was placed in one of them, near the face, drawing air in through one tunnel and out through the other. When the headings were about 1,500 ft. from the shaft, however, the air discharged from the drills was sufficient to keep the tunnel clear, without the fan. At the west end, where small locomotives were used to haul the muck, their smoke caused much trouble.

The tunnels were begun in May, 1905, and completed as to excavation in May, 1908, just three years after beginning. Deducting time lost by the original contractors abandoning the work, the average progress of excavation was 6.26 ft. per day for each tunnel, or 3.23 ft. per day per face (not counting the headings from the central shaft). The best month's work in one heading was 145 ft., or about 5.3 ft. per working day; this represents equivalent full-section excavation, which is stated to be about 95% of the heading advance.

Constructing the concrete lining was done in part after excavation was completed. It was a large task because of the fact that the volume of lining is rather more than half the volume of excavation. Laying cable ducts in the bench walls led to developing various novel expedients for securing an efficient result.* Waterproofing is placed outside the sidewall and arch concrete over part of the length of the tunnels; only 30% of the side walls and only 10% of the length of arch is thus protected, however, although most of the tunnel length is below tide level. Dry stone packing behind the side walls and over the arch was ample to drain all seepage water to the ditches in most parts of the work.

*Eng. News, Oct. 3, 1907, p. 355.

The work was under the same engineering direction as the next section, North River Tunnels. Mr. F. Lavis was Resident Engineer for the Bergen Hill Tunnels. The contract was awarded originally to the John Shields Construction Co., but on the failure of the company was abandoned; it was relet to William Bradley. King, Rice & Ganey sub-contracted for the concrete lining.

Work was begun March 6, 1905, and completed in December, 1908.

Hudson River Tunnels.

This section of the work was described in our columns by Mr. James Forgie, Chief Assistant Engineer,* and is still more fully described in two papers of the series above noted.

The river tunnels are two single-track circular cast-iron tubes 23 ft. in outside diameter, 37 ft. apart on centers, driven by shield and lined with 2 ft. of concrete. They are 6,550 ft. long between shafts, or 6,118 ft. between shield-chambers. The westerly side has a designed gradient of 1.3%, the easterly side one of 1.923%, which were very slightly modified by unavoidable irregularities of driving.

The land sections include 230 ft. of double tunnel on the New Jersey side (between Weehawken shaft and the shield-chamber) and 977 ft. on the New York side (shield-chamber to Tenth Ave.). These sections were partly in rock and partly in earth; nearly all the length was constructed by timbered tunneling, a small part being done by cut-and-cover work.

The river tunnels have an average cover of 25 ft. This is all the so-called Hudson silt, a mud quite fluid when wet, but stiff when the air-pressure was high enough to force the water back. Rock bottom dips to maximum depth of about 300 ft. The instability of the silt was a main point of doubt prior to construction, and because of it Mr. C. M. Jacobs devised the plan of providing, at close intervals in the bottom of the tunnel lining, plates of such form that screw piles could be put down through them to rock.

The lining is of different thicknesses, but the standard has 1½-in. shell thickness, 11-in. flanges, and 1⅛-in. connection bolts. The "heavy" iron, used for most of the river portion, has 2-in. shell thickness. The rings are 30 ins. long. The iron weighs (according to shell thickness) 9,273 to 11,594 lbs. per lin ft., and the bolts, nuts, etc. (127 bolts per ring), weigh 336 to 533 lbs. per lin. ft. of tunnel. Each ring consists of 11 main and one key segment. The special screw-pile segments, called "bore" segments, occurring at 15-ft. centers, add slightly to the average weight; they occur in pairs, occupying the width of two rings, giving a bore for a 30-in. iron pile with a screw point about 4½ ft. in diameter. The plan was to have the pile shaft pass through the tunnel shell without attachment and rest the roadbed on the piles, so that the live-load would not be borne by the tunnels.

Trials with screw piles proved them easy to sink and ample for the duty. But careful observations showed the tunnels to be stable enough and yet have a small oscillation due to tidal variation and load changes, which facts made it seem best to omit using the piles. The bore segments were therefore capped by plain cap plates after the tunnel was finished but not yet concreted.

*Eng. News, Dec. 13, 1906, pp. 603-614, and Feb. 28, 1907, pp. 223-234.

The observations were made chiefly by sinking five 6-in. pipes through the invert to rock, at different points in the river section, and placing iron rods through these pipes into the rock, to give fixed benchmarks. Recording gages at the top showed the relative vertical movement of the tunnel. It was found that at high tide the tunnels were ⅛-in. lower than at low tide (5 ft. tidal difference). Also the wait of a year before lining for making tests, and the addition of the concrete lining, produced a general subsidence of the tunnels by about 0.34 ft. Mr. Jacobs says the settlement has been constantly decreasing since construction and appears to have been due almost entirely to the disturbances of the surrounding materials during construction.

For keeping constant check on level and alinement of the tunnels after completion (regular accurate surveys were of course maintained throughout construction), brass benchmark studs have been set in the concrete lining of the side benches every 300 ft., vernier bars set in pockets of the lining for alinement survey, and the benchmark rods to rock maintained with recording gages. Five 6-in. pipes connecting the tunnels in the river portion, and several cross-passages landward of the bulkheads, assist in furnishing alinement checks.

The tunneling shields were equipped with cylindrical doors on horizontal axis, to enable readiest control of inflowing material to be had. Advance in the silt was accomplished without hand work or timbering at the face, by shoving the shield and forcing the silt in through the doors. Only a few of the doors were kept open for this. Shoving the shield with all doors closed was possible, but forced the tunnel out of line and grade badly. It was finaly found that by opening the lower doors and taking in a certain proportion of the displaced material these troubles were avoided. The nature of work in this material of course was such that the speed of erecting the iron tunnel rings was the principal limitation to speed of advance.

In gravel, landward of the river bulkhead walls, and in passing through the piles and riprap of the bulkheads, very difficult work at the face was encountered, without serious accident, however.

The four shields started at various dates between May 12 and Aug. 27, 1905. The North tunnel was holed through on Sept. 12, 1906; the South tunnel Oct. 9, 1906; the last ring of lining was erected Nov. 18, 1906.

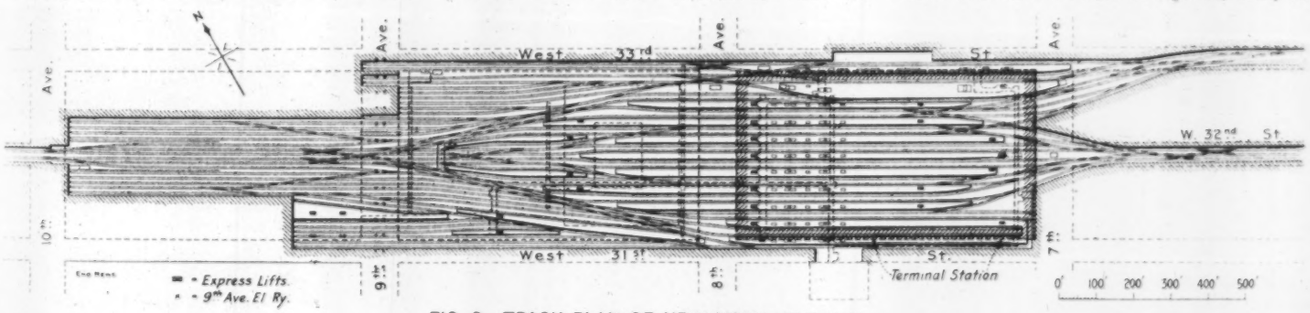

FIG. 8. TRACK PLAN OF NEW YORK TERMINAL.
(11 platforms, 21 platform tracks.)

The average speed of advance of the shield-driven tunnels was as follows:

	Time per ring. hrs.	mins.
Shoving shield and mucking	3	33
Erecting iron	2	15
Lost time	0	13
Unavoidable delays	0	44
Total, 30-in. advance	6	45

The greatest month's advance of one shield was 545.2 ft. The greatest day's advance was 37.5 ft.

The air-pressure ranged from 17 to 30 lbs. per sq. in., with 37 lbs. as occasional maximum.

Some segments in the roof and a few in the invert cracked, but it was thought better to re-

inforce them than to replace them. Turnbuckle rods were fitted to them. All these were landward of the river banks.

The concrete lining is formed with side benches as noted for the Bergen Hill Tunnels, with roof radius 9 ft. 6 ins., width between benches 11 ft. 8 ins., clear height 19 ft., and clear height above top of rail 16 ft. While designed for 2-ft. thickness on roof and sides, it was decided to allow a minimum thickness of 18 ins. at any point, in order to give leeway for equalizing the sinuosities of grade and alinement; a maximum lowering of track of 3 ins. was allowed, i. e., a maximum thickness of roof concrete of 2 ft. 3 ins. Reinforcing rods were also placed in the lining. In top and bottom, 20 1-in. square twisted rods each were placed, 4 ins. back from the face of the concrete, these increasing the longitudinal bending strength of the tunnel structure. At the shore lines and at some points where the roof concrete was specially thin, circumferential 1-in. rods of 10 to 15-in. spacing were put in. Prior to putting in the concrete, the iron lining was calked in all joints with sal ammoniac and iron borings, and red-leaded grummets were placed under bolt heads and nuts.

The final leakage is only about 300 gals. per day per tunnel (6,100 ft.), or about 0.05 to 0.06 gal. per lin. ft. per 24 hrs. A sump at the center of each tunnel was formed by forcing down a special segment of the invert with hydraulic jacks, and attaching hollow castings above, forming finally a concrete-lined pit 16½ × 55½ ins., 11 ft. deep.

The work involved 189,616 cu. yds. excavation, 66,960 tons iron lining, bolts and rods, etc., and 56,618 cu. yds. concrete. After the completion of the iron lining in 1906, calking and grummeting occupied the time till June, 1907, then nearly a year was spent in observations and pile experiments, to April, 1908, leading to the work of capping the pile bore segments, April to November, 1908. Concrete lining was done from then until June, 1909, and cleaning-up operations June to November, 1909, finally completed the work.

Mr. Charles M. Jacobs was Chief Engineer of this section and of the Bergen Hill Tunnels, with Mr. James Forgie as Chief Assistant Engineer. Mr. B. H. M. Hewett was General Resident Engineer for the North River Tunnels, with Mr. W. L. Brown and Mr. H. F. D. Burke as Resident Engineers for the two ends of the tunnels. The contractor for the River Tunneis and the work east to Tenth Ave. was the O'Rourke Engineering Construction Co. (the Weehawken and Manhattan shafts having been constructed by the United Engineering & Contracting Co.). Mr. Geo. B. Fry was General Superintendent for the contractor, with Mr. J. F. Sullivan as Assistant, while Mr. Patrick Fitzgerald was General Tunnel Superintendent.

Terminal Station.

The station and yard site upon which the Hudson River tunnels debouch is an elongated area 213 ft. wide at Tenth Ave., 355 ft. wide at Ninth Ave., and generally 509 ft. wide between Ninth and Seventh Aves., by a total length of about 2,600 ft. The south and north boundaries from Seventh to Ninth Aves. are 31st and 33d Sts., the excavation, however, including these streets, bringing the backs of the retaining walls close to the farther house line. The area at track level between walls is 28 acres. The Hudson River tunnels enter on the line of 32d St. at the west end (Fig. 5). At the east, fan-shaped areas lead off into 33d and 32d Sts., whence the Crosstown Tunnels run east.

The city's consent to close and occupy 32d St. from Seventh to Ninth Aves. was obtained in the general consent to construct the tunnel system. The property covered was generally bought privately, 32d St. was bought from the city, and the sewers and water and gas mains around about the area were reconstructed as conditions necessitated.

The site was excavated down to a general level 40 to 50 ft. below the adjoining streets (40 ft. minimum distance from top of rail to curb), and retaining and face walls of concrete were constructed around the sides. The bottom of the excavation was in rock at all points, and while the surface of rock varied greatly its mean surface was well above midheight. The latter fact is shown by the quantities of excavation for the entire station site (including the westerly part which belonged to the North River section) and the easterly fan-shaped approaches:

Earth	923,800 cu. yds.
Rock	1,516,800 cu. yds.

These amounts are place measurement, loose measurement being about 50% greater.

Excavation was begun by horsetrucking, but only about 10% of the total was thus removed. Locomotive haulage was used for the remainder. The spoil was hauled over a temporary elevated trestle to a pier at 32d St. and North River, where dumping chutes, derricks and telphers were provided for transferring the material to scows. At this same point the Manhattan tunnels under the Hudson discharged their spoil. From here, and from a similar unloading plant at 35th St. and East River, where the Crosstown Tunnels and the East River Tunnels discharged, the spoil was taken away on scows under a contract with Henry Steers, Inc. Of the total spoil taken from both these points, 4,457,800 cu. yds., no less than 3,454,800 cu. yds. was used for filling at the Greenville freight terminal of the Pennsylvania, and 711,900 cu. yds. at the Meadows embankment.

The retaining walls above rock are massive concrete sections designed to resist the entire thrust of the earth behind and to carry various superstructure loads and street loads. Below rock surface they are merely face walls, but with back drained by vertical drains 6 ft. apart to guard against accumulation of water pressure. All the walls are executed in 50-ft. lengths, which was not sufficient subdivision in the absence of longitudinal reinforcement to prevent cracking entirely. Reinforcement was used in a few sections, with success. The faces of all the retaining walls have a minimum batter of 2 ins. per ft., with such change of batter as needed to bring the vertical plane of the toe parallel to the top; this amount of warping of the face is hardly noticeable.

The excavation and wall work was let to the New York Contracting Company—Pennsylvania Terminal, who began work in July, 1904, and finished in December, 1908. The erection of the station building over the easterly half of the site was done by the Geo. A. Fuller Co.

The terminal station excavation and wall work was done under Mr. Alfred Noble, Chief Engineer, with Mr. C. L. Harrison, Principal Assistant Engineer. Mr. Geo. C. Clarke was Resident Engineer.

The station construction was under the direction of Mr. George Gibbs, Chief Engineer Electric Traction and Station Construction. The building was designed by McKim, Mead & White, architects. It is a steel-frame granite-clad structure of striking appearance, as the several half-tone views with this article suggest. Its general height is 76 ft., the maximum 153 ft.; the length and breadth are 788 ft. 9 ins. by 430 ft. 6 ins. The main waiting-room is 314 ft. by 108 ft. and 150 ft. high. The train concourse, which lies above track level, is 340 ft. by 210 ft. and is covered entirely by glass set in the panels of steel arching. There is a separate exit-concourse under the main concourse, to separate incoming and outgoing traffic. Both concourses are connected with the train platforms below by stairways and elevators.

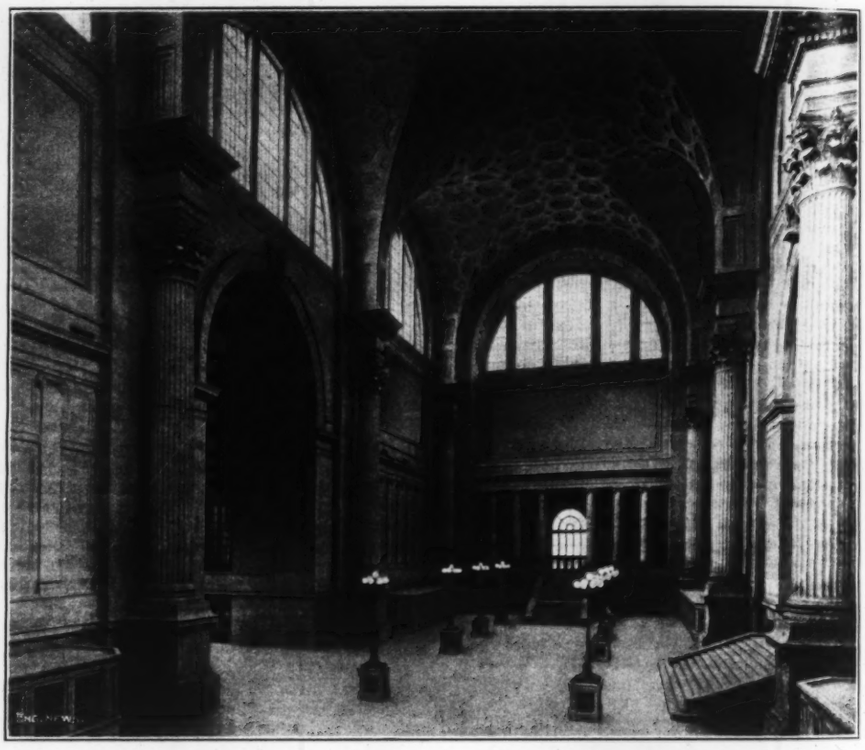

FIG. 9. THE MAIN WAITING-ROOM OF THE NEW YORK TERMINAL STATION.
(Looking north. Entrance from main corridor at right; passage at left to small waiting-rooms and train concourse.)

The track level contains 11 platforms and 21 standing tracks.

The station building was completed in its rough body by August, 1909. Work on the interior equipment was practically completed in spring of 1910. The track and signal work, etc., was among the last items to be completed.

The Crosstown Tunnels.

These two double-track tunnels descend from the Terminal Station eastward along 32d and 33d Sts. on grades of 0.3% to 1.5% to the East River Tunnels. Their larger portion was excavated by rock tunneling from two shafts at the bank of the East River and two shafts between Fourth and Madison Aves. The rock is the typical Hudson Schist which forms most of Manhattan Island.

Each of the two tunnels is divided by a 48-in. concrete wall forming part of the lining into two single track compartments of 8 ft. 2 in. radius of roof arch, 2 ft. 4 in. benches, leaving an 11 ft. 8 in. clear width. Waterproofing extends up the sides outside the concrete, and for a part of the

line also over the arch. The roof of the tunnel is below tide level for most of the length.

Except for a short distance near the river, each of the two double-track tunnels was excavated as a single opening, the division into compartments being accomplished by the lining alone.

The contractor's methods in this part were interesting. A top heading was worked, but the bench was kept so close to the face that practically all the heading muck was blown over the bench. Three heading arrangements were used in various parts: center heading, full-width heading, and two headings with central wall blasted away at a point between heading and bench. A steam-shovel run by compressed air was used for loading the muck, and once loaded it was not again transferred until dumped into scows at the river pier. Special skips of rectangular shape, hinged something like a clam-shell bucket, holding 3 cu. yds., were used for this work. They were hauled on flat-cars in the tunnel by an electric locomotive, and hoisted up the shaft to the surface by telphers running on a timber headframe extending out over the street. The telpher, having hoisted a skip, was run forward, then lowered its skip on a horse-drawn truck, and returned to the shaft for another skip. The truck being carted to the pier, the skip was lifted off by a derrick, swung to the scow, set down, and lifted from its contents by hooking to eyes near the bottom of the sides. The same skips carried sand and stone back to the shaft for concreting, when this was in progress.

This method of handling material was remarkably successful in avoiding noise and smoke (which at the location of the Intermediate Shafts would have been a nuisance) and operated very smoothly and efficiently.

The rock was generally firm enough to permit full-section excavation without timbering. Loose rock was met at several points, requiring very careful roof timbering, especially at one or two points where the rock cover was very thin, as alongside the Interborough rapid-transit subway in Fourth Ave. In the best rock rates of advance up to 3 to 5 ft. per day were made.

Bad conditions were encountered between Fifth and Seventh Aves. in both streets. Here the rock surface dipped below the roof line, and a change of plan was decided upon, lowering the tunnel level and doing away with a long stretch of very flat grade which was to have served as standing track for trains approaching the station. Also, the section west of Sixth Ave. was built largely as open-cut work.

The contract was let to the United Engineering & Contracting Co. Work was begun in June, 1905, and completed (except for restoring streets) in March, 1909. The engineering organization was the same as for the East River Tunnels.

East River Tunnels.

The four single-track river tunnels, averaging 3,902 ft. long between shafts, are shield-driven circular cast-iron tubes exactly like those of the Hudson River, but having no provision for pile foundations. They were started from a pair of shafts on the Manhattan side and a pair on the Long Island side, each taking two tunnels. The shafts are steel caissons, 40 × 74 ft., with walls 5 ft. thick filled with concrete, and a 6-ft. dividing wall to separate the two tunnel compartments. Those on the Long Island side were sunk with compressed air to 78 ft. below M. H. W., of which two-thirds was through rock. Those on the Manhattan side were sunk open, and stopped at 31 ft. and 38 ft., respectively, below M. H. W., the lower part of the shaft being in good rock.

The river tunnels were driven by eight shields. These have a double diaphragm, arranged to serve as air-lock, so that a higher pressure could be maintained at the face than behind the shield. This feature was not brought into use, however, and in fact the early experience in rock face showed the closed diaphragm to be a serious handicap. A large opening was then cut through the lower part of the diaphragm of each shield.

The nature of the ground was known to be radically different from that in the Hudson. Both ends of the work are in rock, and at the center of the crossing is a rock reef rising well above the line of the tunnels. The two channels between are filled with various soft materials, clay and gravel, disintegrated rock, quicksand, etc. Great difficulties were anticipated and realized in the sand strata and at the junction between rock and soft ground.

The cast-iron lining was the same as used in the Hudson River, but generally lighter, the 1½-in. shell thickness being used in the river tunnels, with only a few segments of 1¾-in. and 2-in. shell thickness for strengthening adjacent to broken segments. In the land sections the shell thickness was 1-in. or 1¼ ins., and the flange depth 8 and 9 ins., respectively (as compared with 11 ins. for the standard lining). Messrs. Brace, Mason & Woodward record that the rings after erection showed an average of 1 7-16 ins. shortening of the vertical diameter, which was more than had been expected. Turnbuckle rods and pulling jacks acting in the horizontal diameter were used to hold the rings truly circular prior to shoving the shield and when finally tightening up the bolts.

Broken segments to the number of 319, or 0.42% of the total number, occurred. Most of these broke when close behind the shield. Some few were replaced before the shield had progressed another ring, but in sand this work was deferred until after junction of the tunnels, when the air pressure was raised high enough to dry the sand under the break and the segment was then drilled and broken apart. Cast-steel segments were pulled into place of the broken ones. Some slight breaks were simply calked, or were reinforced by tie-rods across the plate; all these points also were later strengthened by placing reinforcing rods in the concrete lining.

The work of advancing the shields was very difficult and dangerous in the sections where the face was rock below and sand or boulders above, and also in much of the soft-ground portion. Sliding hoods, operated by screws, had been fitted to the cutting edges for these conditions, but they were soon discarded for fixed hoods. Advancing with a carefully timbered face was not sufficient to prevent "blows," and practically over the whole crossing it was necessary to dump a thick blanket of clay on the river bottom over the tunnel to prevent excessive loss of air. Even the clay blanket, carried to thickness of over 15 ft. in some parts, was liable to be eroded or broken through by escaping air under specially bad face conditions. The total amount of clay dumped as blanket was about 400,000 cu. yds., and its placing and removal cost $304,056.

The air pressure was practically always kept about equal to the hydrostatic head at mid-height of the face. The pressure generally was 30 to 34 lbs. gage, but in the worst sections a pressure of 37 lbs. was maintained for a considerable time, while on the other hand in the firmer material near the central rock reef pressures down to 28 lbs. could be used. During repair of broken segments, pressures of 38 to 40 lbs. were maintained, and for a short time 42 lbs. was carried.

The greatest average 24-hr. consumption of air was 19,000 cu. ft. per min. for one tunnel, in one of the Manhattan headings, and prior to this a single tunnel had averaged as high as 15,000 cu. ft. free air per min. for 24 hrs. On the Long Island side the greatest figure was 12,700 cu. ft. per min. maintained during 24 hrs., and the maximum day's average for the four headings was 33,400 cu. ft. per min. The figure for one tunnel is far higher than the corresponding air consumption at any time in the North River section.

The difficulties throughout were greatest on the Manhattan side, and here the greatest divergence from grade occurred, through a combination of thin cover, ground disturbed by pile-driving, broken segments, and the presence of riprap. A shutdown of this heading for three weeks to allow the river bed to consolidate helped matters.

The full pressure of the 27 jacks was sometimes required to advance the shield, when working in soft ground. As under these conditions the hydraulic pressure sometimes even exceeded the designed 6,000 lbs. per sq. in., the gross shoving force was greater than 5,154 tons, the jacks having 9-in. plungers.

The rates of progess of the shields in the river section varied greatly. The Long Island side progressed most rapidly, and from Nov. 1, 1907, to March 1, 1908, the four shields of this side averaged 8.74 ft. per day per shield. The Manhattan shields rarely ran above 2 to 3 ft. per day for any considerable time.

Grouting through holes in the lining to fill the annular void outside was done wherever possible. A modified quick setting natural cement was used, English Blue Lias lime and an American hydraulic lime having proved unsatisfactory.

Calking was done at first with iron filings and sal-ammoniac, but it was not wholly satisfactory, and after a trial of lead wire this alone was used.

The concrete lining was placed largely in summer, and later developed cracks about 30 ft. apart, with some leakage. Drilling rows of holes along the leaks and pounding neat cement mortar and small plugs of cement mortar set 5 or 6 hrs. into them with a calking tool and sledge hammer was effective in reducing the leakage. The final leakage is only about 0.35 gals. per lin. ft. per tunnel per 24 hrs. A sump at the lowest point, built as a passage between and below the tunnels, with pumps, takes care of the drainage.

The land sections of iron-lined tunnel, about 2,000 ft. of each tunnel on the Long Island side between the steel-caisson shafts on the Long Island shore and a large shaft built at East Avenue, were driven partly in normal air and without shield, partly by shield under air pressure, and partly under air pressure without shield. A shield was tried without air pressure, but the attempt failed through weakness of the shield. Much of this land section is in rock, but portions run through soft ground, where even with the aid of the shields it was not possible to avoid settlement of the ground surface.

The East River Section, the Crosstown Tunnels and the excavation and wall construction for the Terminal Station were all combined as East River Division, under Mr. Alfred Noble as Chief Engineer, with Mr. C. L. Harrison as Principal Assistant Engineer. Mr. J. H. Brace was Resident Engineer of the west headings of the river tunnels corresponding to the 33d St. line; Mr. F. M. Mason was Resident Engineer for the 32d St. tunnels, both Crosstown and west river headings. The 33d St. Crosstown section was at first in charge of Mr. George Leighton, and later of Mr. J. H. Brace in addition to his river section. The Long Island headings under the river and the Long Island section of all four tunnels were in charge of Mr. S. H. Woodard.

S. Pearson & Son, Inc., a sub-organization of the English firm of similar name, were contractors for the river section. They worked under a cost-plus-fixed-profit agreement, sharing additional profits and any loss. Mr. E. W. Moir and Mr. Henry Japp were in direction for the contractor.

The contractor began work on May 17, 1904, and finished exactly five years later. Compressed-air work behind the shields began on the Manhattan side at various dates from Oct. 5 to Dec. 1, 1905, and on the Long Island side from June 2 to Oct. 16, 1906. The shields met between Feb. 20 and March 18, 1908, so far as to permit passage through, though the projecting platforms had to be cut away before the actual junction of the cutting-edges could be effected.

The east approaches to the shield-driven work comprise approach tunnels built as cut-and-cover work (unlike the shield-driven work these are not lined with cast-iron) and short revetted cuts, leading into Sunnyside Yard. These sections, together with the westerly portion of the yard work, were built by Naughton Company and Arthur McMullen, and were in charge of Mr. Geo. C. Clarke as Resident Engineer. Mr. C. W. S. Wilson was Resident Engineer for the contractors.

Their tunnel sections vary from 1,100 to 2,060 ft. long, and aggregate 6,950 ft.; the revetted approaches total 2,555 ft. (these are separate for two of the tunnels, while the southerly tunnels have a common portal and approach cut). The approach gradients vary from 1.22% to 1.9%. Part of the tunnel section is on 1° 30′ curve.

A special feature of the tunnel approaches is that Tunnel C, next to the southerly one, crosses

FIG. 10. TRAIN PLATFORMS AND CONCOURSE IN THE PENNSYLVANIA R. R. NEW TERMINAL STATION IN NEW YORK CITY.

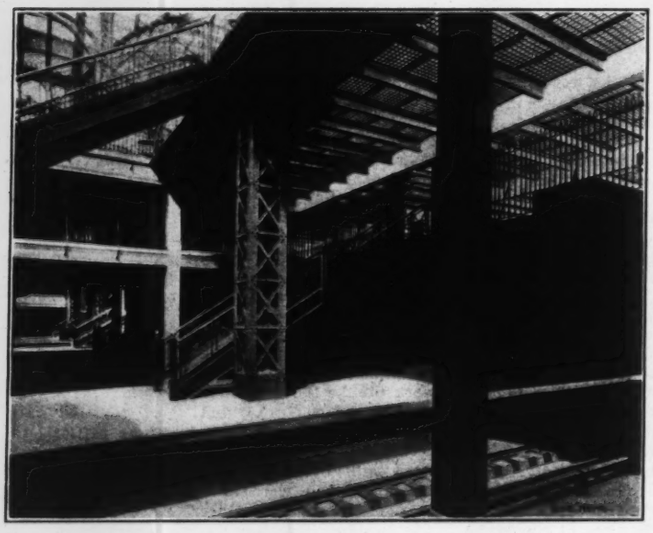

FIG. 11. VIEW FROM TRAIN PLATFORM SHOWING EXIT CONCOURSE WITH STAIRWAY SEPARATE FROM STAIRS TO TRAINS.

northward over its neighbor, so that while the order of the river tunnels is A, B, C, D, beginning at the north, the portals are in the order A, C, B, D. This is because the 32d St. tracks and the 33d St. tracks in Manhattan are to be worked as independent double-track lines, and it was desired to avoid a grade-crossing in bringing the two eastbound tracks together at the south and the two westbound tracks together at the north, in the yard.

The internal contour of the cut-and-cover tunnels is similar to that previously described, except that the side benches are reduced by 8 ins., to a width of 3 ft. The shape of the exterior is varied, however, to suit the ground, both rock and soft ground subsoil being met. The soft-ground portions generally rest on piles, and have a thick floor to distribute the load. At the crossing of Tunnel C over Tunnel B, the latter is in rock, and no special device was required except thickening and reinforcing the roof of B to carry the burden. Where C passes beyond B, rock is much below the top of B, and a cellular construction of concrete walls was built up to carry C, thus saving concrete, and this viaduct-like structure was continued to the portal of C.

The westerly portion of the yard, embraced in this contract, was largely fill in marsh. It includes several viaducts carrying streets over the yard.

Sunnyside Yard.

The yard is 8,500 ft. by 1,625 ft. in greatest dimensions, and covers 208 acres. It contains two main banks of yard tracks (42 and 45 tracks, respectively), a loop turning track around the east end, a small freight yard near the west end, and running and sorting tracks. There is space for a further 32-track bank, which would make the ultimate capacity 1,387 passenger train cars. The present two banks of passenger-yard-tracks will serve multiple-unit motor-car trains, and locomotive trains, respectively. The tunnels lead out of the yard at the west, and nearby there leads off a group of tracks to a set of freight and car-ferry piers on the East River. At the east end of the yard two lines of tracks lead to the main line and to the North Shore Division. The eastbound track of the latter is carried over the westbound main line tracks by viaducts, avoiding a grade crossing.

Part of the yard area was swamp, but a large part was high ground, requiring excavation to get to track level. This was all in earth. More material was excavated than the fill of the marsh area consumed. Four streets were carried over the yard on viaducts.

The excavation and substructure work for the yard was done by the Degnon Realty & Terminal Improvement Co. The yard buildings were

erected by the John W. Ferguson Co. The work was in charge of the East River Division (Mr. Alfred Noble, Chief Engineer), and Mr. L. H. Harker was Resident Engineer.

The finishing work in the yard, as well as tracklaying, etc., was done under the division of Electric Traction and Station Construction, Mr. George Gibbs, Chief Engineer.

Equipment and Electric Traction.

The subject of track, signal and other equipment is to be treated in a paper of the series earlier noted, not yet published. Generally speaking, 100-lb. rail on ties carried by stone ballast is used, except in the Terminal Station, where the rail is supported by short blocks embedded in the concrete of the floor, with screw fastenings. The third-rail (for 600-volt supply) is of special composition and section and is carried on insulators set on long ties (about every fifth tie). Pockets for conductor supports are cored in the roof concrete of the tunnels at 10-ft. spacing, doubtless to give future opportunity for using overhead conductors if desired. These are not used at present, however.

Power is to be supplied from the Long Island R. R. generating station in Long Island City, which is capable of extension to 105,000 KW. output capacity. The 11,000-volt transmission is carried in cables enclosed in ducts embedded in the concrete benches of the tunnels, but along the Meadows crossing it is carried by a steel tower transmission line along the embankment, this line having space for four three-phase circuits and several auxiliary lines.

The powerful electric locomotives built for this work as the result of special designs and tests have already been described in our columns (Nov. 11, 1909). The Long Island suburban traffic is operated by multiple-unit trains.

Sterilization of Polluted Water By Ultra-Violet Rays.

By KENNETH C. GRANT,* Assoc. M. Am. Soc. C. E.

A very interesting set of experiments is being carried on at the physiological laboratory of the Sorbonne in Paris to perfect a practical application of the sterilizing effect of ultra-violet rays to the purification of polluted water. The bactericidal action of these rays has been known for some time; the earliest positive mention of their successful use is in 1877, by two English scientists, Downes and Blunt. It is only within a few months, however, that anywhere near adequate disinfection of water in large quantities has been attempted with the idea of developing a commercial process for public supplies. The experiments herein described show that the use of the radiations on a large scale, to say the least, begins to become feasible.

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The process, in brief, consists in exposing the water to the ultra-violet rays from a quartz-tube mercury-arc lamp ("Westinghouse Silica" type) suspended above and close to the surface of the liquid; the microorganisms found therein being killed by the direct action of the ultra-violet rays, without the evaporation of the dissolved gases, the precipitation of the soluble salts or the intermediary formation of ozone or oxygenated water either of which might alter the taste and composition.

The apparatus for the Sorbonne experiments is very simple (Fig. 1). A tank is filled with water from the Paris supply. The water is inoculated with about 5,000 microbes per c. c. A small electrically-driven pump raises the water

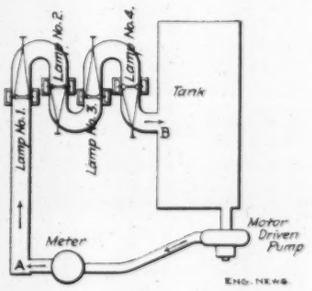

Fig. 1. Arrangement in The Sorbonne Laboratory For Studying the Bactericidal Effect of Ultra-Violet Rays.

from the tank to the trough A B, passing through a meter, which gives a record of the flow, also obtained as the water returns to the tank at the end of trough B. The lamps are placed over the tortuous part of the trough as shown in Fig. 1, the individual lamp arrangement being as shown in the cross-section of the trough, Fig. 2. The bacteria-laden water passes through the trough from A to B, the quantity being regulated by the speed of the pump and as it passes under the lamps it is exposed to the ultra-violet rays. The results are best appreciated from a glance at Fig. 3.

This diagram is made from a study of samples taken when the water was flowing through the trough at a rate of about 1,270 cu. ft. per hr. Two lamps only were used, each requiring 660 watts per hour; 1.32 KW.-hrs., therefore, gave 1,270 cu. ft. of sterilized water, or at the rate of 960 cu. ft. per kilowatt hour. At a cost of one cent per kilowatt hour, therefore, it costs about $1.40 for lamp energy to sterilize 1,000,000 gals.

Fig. 2 shows the construction of the lamp, the arrangement of the reflector, and the floating device for keeping the light at a uniform distance (2 cm.) from the water surface. The tube for the lamp is blown in the very peculiar shape shown, with a U-tube at each end having a platinum seal at the contracted portions. The shaded portion of the tube shows the parts containing mercury, the portion between the platinum seals and the ends of the tube being for the purpose of insuring that the seals are absolutely airtight. The cups or shields at each end of the lamp are for the purpose of keeping the water from the U-tube. There is, of course, a vacuum in the tube as in the more familiar Cooper-Hewitt lamp. To light the lamp the current (220 volts direct) is switched on and the tube is raised slightly at the positive or bulb end by means of the starting handle and suitable connecting levers (L-L). The mercury in the bulb runs down to the other end and a short circuit is made. When the tube is thrown back into its original position the mercury stream is broken, an arc is sprung and the tube becomes highly luminous. The tube is not worked with as heavy current and as high temperature as the quartz tube lamp will permit for then the color value changes and the formation of the ultra-violet rays is greatly decreased. The ultra-violet rays with the other radiations are concentrated upon the water flowing along the trough below by a reflector. The chief difference between these lamps and the ordinary Cooper-Hewitt type used for general illumination is in the character of the glass used for the tubes, the latter having tubes of ordinary lead glass, which is practically a complete absorbent of ultra-violet rays; while the molten quartz glass used for these sterilizing lamps is fused at a very high temperature and allows practically full passage of the ultra-violet rays produced by the arc between the electrodes. The light produced by these lamps is injurious to the eyes and suitable glass goggles have to be worn in working around the apparatus.

These experiments have successfully demonstrated the commercial possibility of purifying water in large quantities by this process. They are being continued in the attempt to increase the efficiency; this is being done by passing the water through a specially constructed chamber or valve in the trough by means of which it is three times exposed to the rays of the same lamp.

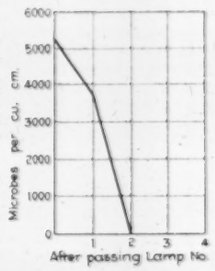

Fig. 3. Disinfection of Water by Ultra-Violet Rays.

The clearness of the water used is an important factor in obtaining high efficiency. A turbid water, offering resistance to the passage of the ultra-violet rays must pass the light with a less depth and a lower velocity. In any installation for purification of a large supply, therefore, it will be necessary, in many cases, to include in the scheme a suitable type of filter for prefiltration purposes, at times when the water is turbid.

The first attempt to put this method of purification into practice is at Marseilles, France, where an experimental plant is being operated in competition with several other types of filtration and purification works.

There is a very strong public sentiment in Europe against the introduction of any chemical into water for domestic supply for purposes of purification. The sterilization effected by the ultra-violet rays is therefore calculated to be received with great favor abroad. The writer believes that this type of purification could be used to great advantage by many cities in the United States where the supply comes from a source in constant danger of pollution.

These experiments are being carried on by Drs. Henri, Helbronner and Recklinghausen, and the writer is particularly indebted to Dr. Recklinghausen, of the Westinghouse Cooper-Hewitt Co., Ltd., Paris, for the opportunity of seeing the experiments at the Sorbonne and for the drawings and data connected with this work.

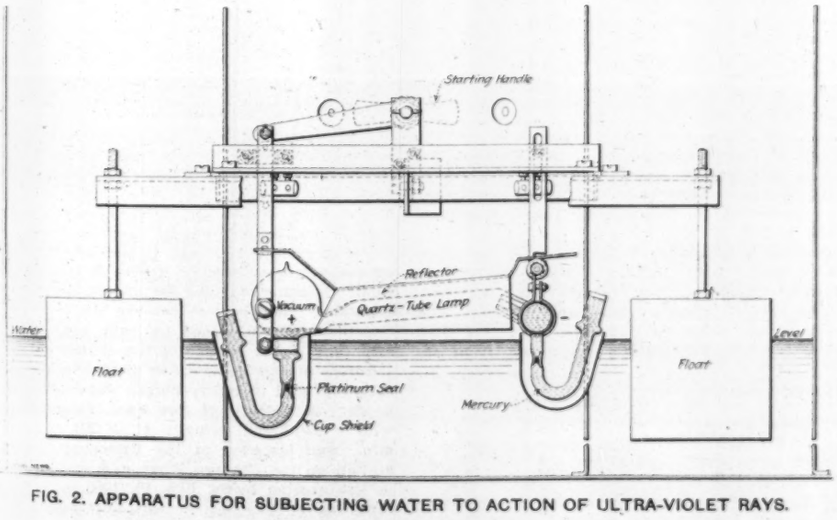

FIG. 2. APPARATUS FOR SUBJECTING WATER TO ACTION OF ULTRA-VIOLET RAYS.

Recent Developments in Rotary Engines.

During the past two or three years a few rotary engines have been built and tested which have shown enough superiority in results obtained to distinguish them from the many thousands of unsuccessful engines of this class which have been patented.

The rotary engine has long been one of the favorite themes of the inventor; but in the great majority of cases it has proved to be a will-o'-the-wisp. It is recorded that James Watt patented and built a rotary engine in 1782.* He eventually reached the conclusion, however, that instead of being simpler, the rotary engine involved more complications and difficulties than the reciprocating type.

The first reasonably successful rotary of which any record has been found in the technical press was the Noteman engine, built about 1880.† This engine developed, in a test, 125 HP., or 43 lbs. of steam per horsepower-hour, but in spite of this fairly creditable performance it was never made a commercial success. Better results were obtained in 1903 with the Cooley epicycloidal engine.‡ Well authenticated tests showed a steam consumption of 42.83 lbs. for a 10-HP. engine, and for a 70-HP. engine developing 26 HP., the steam rate was 31.2 lbs. per B. HP.-hr. (See Table I.) Even more recently the Herrick engine, developing about 20 B. HP., gave a water rate of 44.2 lbs. per B. HP.-hr., and the Harriman engine has given a rate of 41.34 lbs. for a 5-HP. model and 31.02 lbs. for one of 25-HP. The Herrick and Harriman engines are to be described in the present article. A description is also given of a third engine, the Augustine, which is of interest in that it represents a third fairly simple class of rotaries, although no authoritative tests have as yet been made upon it.

Classification of Types.

Thousands of rotary engines have been patented, all more or less different in design, and it is probable that all practicable arrangements differing in essential features have been tried. It is doubtful, in other words, that any great new principle will be discovered: future development will lie in the improvement of mechanical details and proportioning of parts. The more successful engines of the present day are merely improved models based on principles which have long been common property.

The term "rotary engine" should be applied only to those in which the work is done by the direct pressure of the confined working fluid on a piston or rotor moving in a closed circular path relative to the shaft. The rotary engine should be distinguished from the turbine, in which the work is done not by expansive pressure but in part at least by the momentum of rapidly moving jets of the working fluid. Distinction should be made between the true rotary engine, as defined above, and those modifications of the reciprocating engine in which cylinders and pistons revolve together about a fixed shaft, while maintaining a reciprocating action relative to each other. Such an engine, of the internal combustion type, was described in Engineering News, Sept. 10, 1908, p. 274, and the Almond so-called rotary steam engine§ is another example of this class.

The essential elements of a rotary engine are three: cylinder, piston (or rotor) and abutment. A classification and subdivision of the various possible types of rotary engines may be based on variations in the form and arrangement of these three essential features. Five main classes are distinguishable on the basis of differences in the form and arrangement of the rotor, as follows.

Class I. Rotor mounted concentrically in cylinder and having projecting pistons. Fig. 1, (a), (b).

Class II. Two driving rotors on separate shafts in two adjacent intersecting cylinders, each rotor having projecting pistons meshing with those of the other rotor. Fig. 1, (c).

Class III. Cylindrical rotor mounted eccentrically in cylinder, on shaft central to cylinder. Fig. 1, (d).

Class IV. Cylindrical rotor mounted eccentrically in cylinder on shaft central to rotor. Fig. 1, (e).

Class V. Disk rotor rolling on two opposite cylinder walls which form the two nappes of a right circular conical surface. The third wall of the cylinder is the central zone of a sphere and is in sliding contact with the edge of the disk.

Discussion of Types Classified.

In Classes I. and III., several different types of abutment may be used. The three principal kinds of abutment—sliding, rotary and swinging—are shown in Fig. 1, (a), (b) and (d). Any one of these three may be used in connection with Class I. or Class III. rotors. The sliding and swinging abutments, when used with rotors having projecting pistons, have to be actuated by separate mechanisms (usually cams or links); but when used with an eccentric rotor, the rotor itself actuates the abutment. For this reason, the rotary abutment is the one most commonly used with Class I. rotors and the sliding and swinging abutments have been used more generally with Class III. rotors.

Rotors of Class I. can be made with hinged pistons, which can be swung back into recesses in the body of the rotor while passing the abutment, or with sliding pistons which are drawn back into their slots in the rotor drum. With either of these arrangements, the abutment remains stationary. A rotary pump of Class I. with sliding pistons and stationary abutment was described in Engineering News, March 1, 1900, p. 152.

Another subdivision of Class I. may be made for engines with circular pistons and torus-shaped cylinders, that is, annular cylinders, whose radial cross-sections are circles. The body of the rotor, in this type, is a thin disk with the circular pistons projecting from its periphery. A rotary abutment is used. The expense of machining the [illegible] and the piston packing rings would [illegible] a considerable obstacle to the commer[illegible] cess of engines of this type.

The abutment in Class II. is formed [illegible] rotors themselves at the point of mut[illegible] tact. This contact can be at best no m[illegible] a rolling, line contact, and is not tight [illegible] any very high pressure. Heavy leakage [illegible] abutment results, and makes a good [illegible] hardly probable at high pressures with a[illegible]

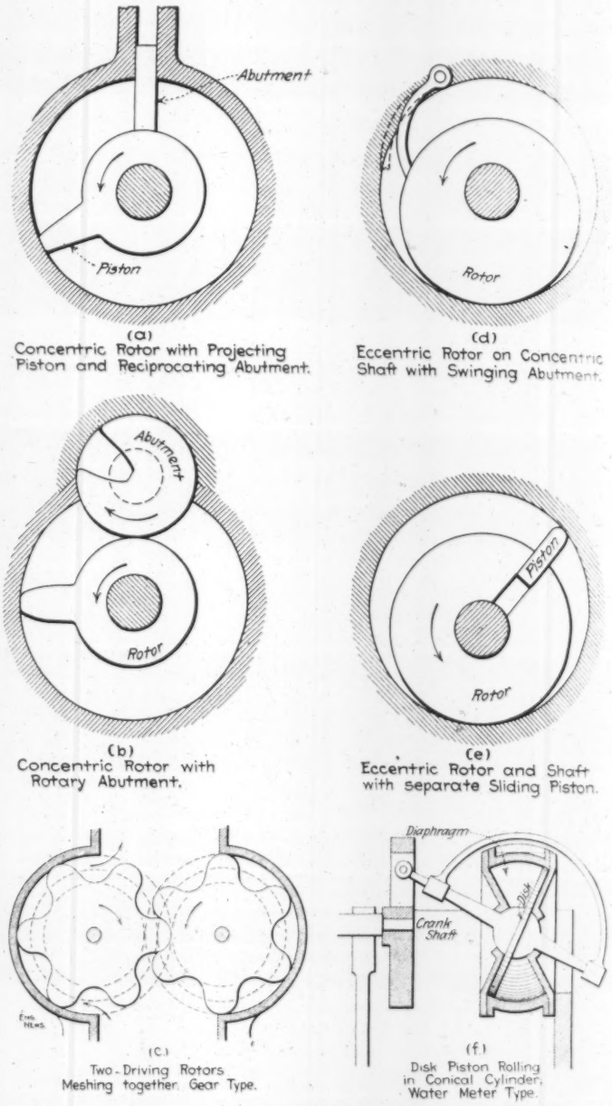

FIG. 1. DIAGRAMS SHOWING FIVE MAIN CLASSES OF ROTARY ENGINES.

of this type. Modified rotors of Class II. are successfully used in rotary blowers—for example in the Root blower and in the Sturtevant pressure blower, described in Engineering News, Feb. 1, 1906, p. 134. In these blowers, the pressure is usually not over 10 lbs. per sq. in., and the leakage is not enough to seriously affect the efficiency, even though there is generally a small clearance, instead of contact, between the impellers. The correct relative position of the impellers is maintained by spur gears on the same shafts but outside of the cylinders.

Rotors of this type (Class II.) have been successfully used in rotary pumps, especially at low heads. A battery of five such rotary pumps, with a combined capacity of 33,250 cu. ft. per min., was installed at the Bridgeport pumping station on the Chicago River and was described in Engineering News, Feb. 19, 1903, p. 172. The total lift at this station was only about 10 ft.

*"Engineering Magazine," May, 1897: Article on history of the rotary engine, by Elmer S. Farwell.
†"The Engineer," (Chicago), Jan. 15, 1901; p. 31. Briefly mentioned.
‡"Machinery," May, 1903, description with report of tests.
§"American Machinist," Nov. 4, 1897; illustrated description.

TABLE I.—RESULTS OF AUTHENTIC TESTS OF ROTARY ENGINES.

Name of engine.	Date of test.	Steam press at engine.	Vacuum at engine.	Superheat, 93.7° F., 3° F. R.p.m.	Horse-power developed	Lbs. steam per HP.-hr.
Cooley	March, 1903	126 lbs.	8.5 ins.	980	10.5	42.83
Cooley	March, 1903	90 "	17.6 "	699	26.0	31.20
Herrick	Dec., 1909	115 "	19.2 "	1,008	19.0	43.80
Harriman	Nov., 1908	126 "	23.7 "	564	5.4	41.34
Harriman	Jan., 1910	136 "	21.7 "	498	25.7	31.02

An analytical discussion, by Mr. John T. Wilkin, M. Am. Soc. M. E., of the action of this type of pumps and blowers was published in Engineering News, Dec. 11, 1902, p. 496. Mr. Wilkin expresses the opinion, in the article referred to, that such impellers are unsuitable for working with an elastic fluid with differences of pressure of more than 5 lbs.

The eccentric rotor mounted on a shaft central to itself (Class IV.) forms its own abutment at its line of contact with the cylinder wall. The principal chance for variation in different models

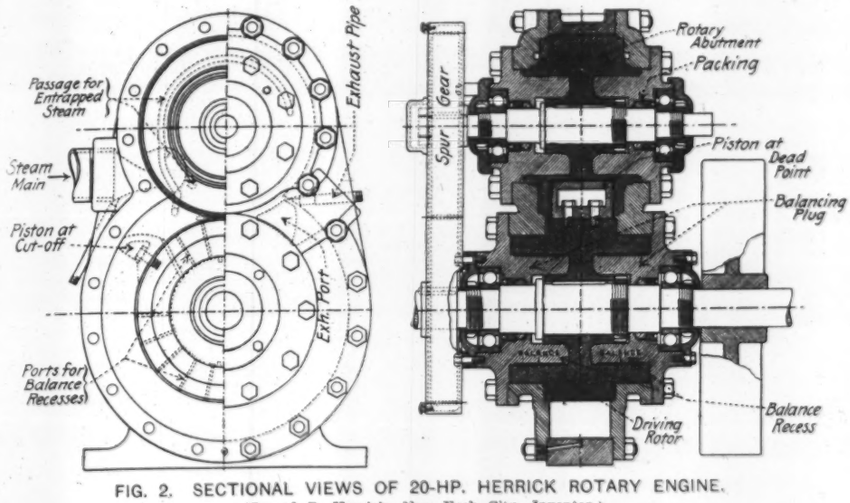

FIG. 2. SECTIONAL VIEWS OF 20-HP. HERRICK ROTARY ENGINE.
(Gerard P. Herrick, New York City, Inventor.)

of this type is in the method of keeping the edge of the sliding piston always in contact with the cylinder wall. A common device is to have projections on the ends of the piston blade fit into circular grooves in the cylinder head. The grooves are made concentric with the cylinder and keep the piston in the desired position throughout each revolution.

In the disk type (Class V.), the abutment is formed by a radial diaphragm which is fixed to the cylinder walls and forms a stop across the

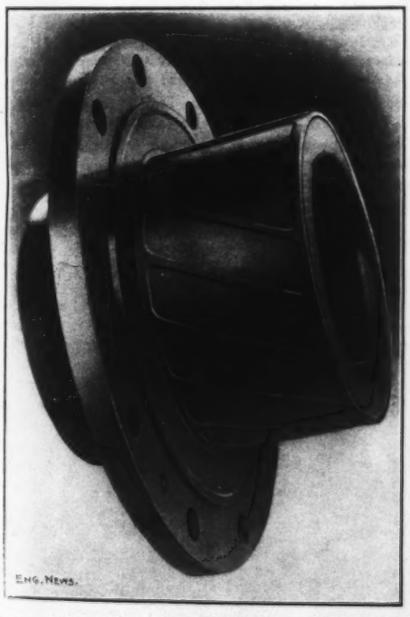

Fig. 3. Balance-Chamber Plug of the Herrick Rotary Engine.

cylinder space from the center radially outward to the spherical wall. The disk piston has a slot which receives the diaphragm, and provision of some sort is made at the slot to allow the disk to both slide and dip, relative to the diaphragm, during each revolution. Steam engines of this type have been built but none has been particularly successful. The disk water meter, however, is a common example of a satisfactory water motor constructed on this principle, but the power developed is, of course, insignificant.

Types Not Classified.

Three other general types of rotary engines might possibly be regarded as separate classes in addition to the five mentioned above, but they are of comparatively little importance; moreover two of them may be considered as belonging to classes already named. The three types referred to are the vibrating type, the screw type and the bucket chain type.

The bucket chain type has pistons attached to a chain running over two sprocket wheels one of which is keyed to the driving shaft. One leg of the chain between the wheels passes through a cylinder. An abutment is arranged to slide into place behind each piston as it enters the cylinder and is slid back out of the way after one piston leaves the cylinder and before the next piston enters. There is some question as to whether this type comes within the definition of a rotary engine.

The screw type is apparently not a very popular one among inventors of rotary engines, and no successful engine of this type is known to have been built. It is better represented among rotary pumps, for example, by the Quimby pump, which was described in Engineering News, June 18, 1896, p. 398. It consists essentially of two worms, or screws, mounted side by side on parallel shafts and enclosed in a closely fitting casing. The threads of the two worms intermesh and they revolve in opposite directions. This type may be considered as a subdivision of Class II.

Vibrating piston engines may be put in Class I. They differ from the examples diagrammed in Fig. 1 (a) and (b) in that there are necessarily two, or some multiple of two, pistons, which are so connected to the shaft that one piston can remain stationary, or nearly so, while the other makes its working stroke. The two pistons of each pair alternate in acting as piston and abutment.

The Herrick Rotary Engine.

A fairly successful engine of Class I., with a rotary abutment, has been recently tested by Prof. Frederick L. Pryor, at Stevens Institute of Technology, Hoboken, N. J. Sectional views of this engine are shown in Fig. 2. The rotor with its solitary, rigidly attached piston is mounted centrally in the cylinder and is keyed to a horizontal shaft. The rotary abutment is keyed to a second horizontal shaft vertically above the main shaft and driven by the main shaft through a pair of equal spur gears. The abutment has a recess which permits the piston to pass the point of contact between abutment and rotor. A feature regarded by the inventor, Mr. Gerardus P. Herrick,* of New York City, as being of the utmost importance is the balancing of the radial steam pressure on the rotor, which relieves the main bearings of the friction load otherwise imposed upon them.

BALANCING AGAINST RADIAL PRESSURE.—The working steam in the cylinder exerts a considerable pressure radially on the main bearings. This pressure is somewhat analogous to the pressure exerted on the crank-shaft bearings of a reciprocating engine through the medium of the piston rod, connecting rod and crank. This pressure is balanced in the Herrick engine by admitting steam from the cylinder to suitable recesses beneath the rim of the rotor.

As shown in Fig. 2, the rotor has a wide rim projecting on each side into a corresponding circular slot formed between the inner edge of the annular cylinder wall and the "balancing plug." The balancing plug is in the form of a wide collar which encircles the shaft and the hub and fits within the projecting rim of the rotor. Two of these plugs are required, one on each side of the rotor. The form of the recesses between the plug and the rotor rim is shown in Fig. 3. They are wide helical slots, 1/32-in. deep, cut on the outer cylindrical surface of the plug.

ROTOR AND ABUTMENT.—The shaft of the rotor, as well as that of the abutment, is mounted in ball-bearings. The piston, as shown in Fig. 2, has an involute form on its working face so as to approximate a continuous contact with the abutment during the passage through the recess. The outer extremity of the piston clears the cylinder wall by less than .001-in., and the fit between the sides of the piston and the flat walls is even closer. Three or four parallel grooves, one of which is radial, on each flat side of the piston assist in obstructing the leakage of steam past these surfaces. Some steam may work its way in, around the ends of the balance plugs, to the shaft; and to guard against excessive loss by such leakage, the shaft is run through stuffing boxes which are located between the rotor and the bearings. The abutment shaft is similarly packed.

The abutment is made with a probably unnecessarily irregular cross-section, with the intention of minimizing the leakage of steam inward toward the shaft. The recess in the abutment entraps some of the high pressure steam at each revolution; and unless some precaution were taken, this entrapped steam would be carried around and delivered to the exhaust port. To prevent this, passages are provided through

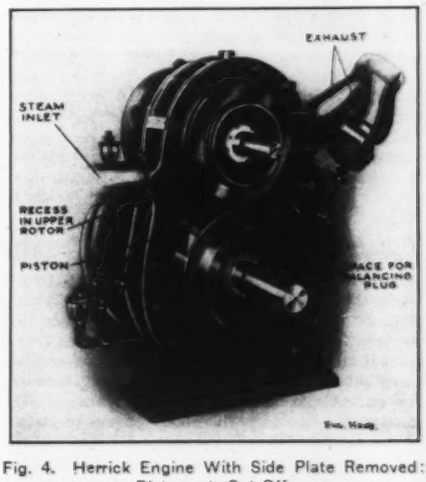

Fig. 4. Herrick Engine With Side Plate Removed: Piston at Cut-Off.

which most of the steam entrapped in the recess can flow back into the cylinder behind the piston. Concentric passages in the sides of the abutment casing communicate with passages through the walls of the abutment recess, and continuations of the concentric passages communicate with the cylinder, as shown in Fig. 2. Thus the entrapped stem is enabled to expand down to the exhaust pressure before the recess is open to the exhaust.

*Herrick Engine Co., 74 Broadway, New York City.

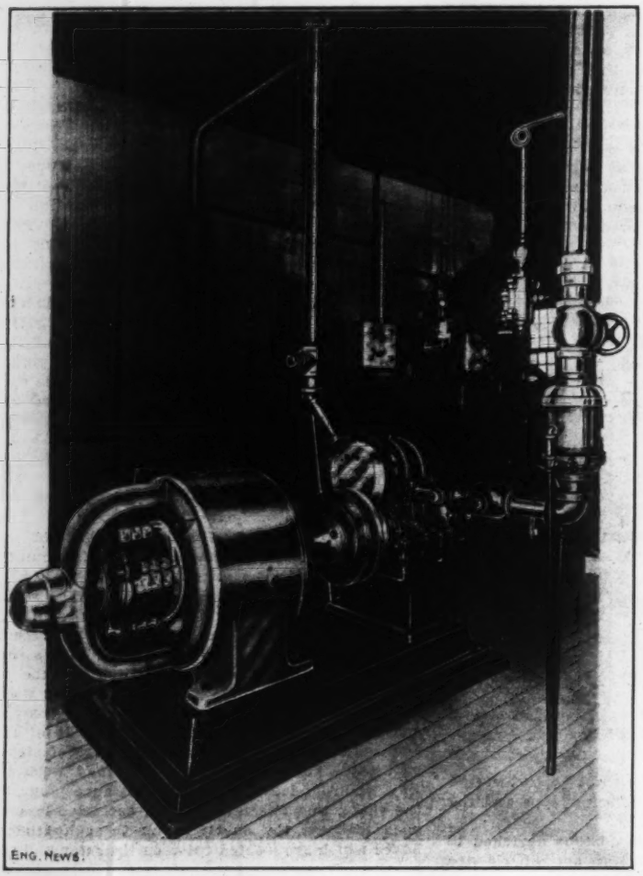

FIG. 5. HERRICK ENGINE DIRECT-CONNECTED TO GENERATOR.
(Photo taken during the 1685-hour endurance run.)

sion of entrapped steam from the abutment recess, which begins at about 2/11 of the working stroke. An indicator card from this engine would be interesting, but none are available.

DIMENSIONS. — The weight of the engine, which is not lagged, is given by the makers as 835 lbs., or about 40 lbs. per horsepower. The engine stands on a base 16 ins. × 4 ins., and occupies a space 17 ins. × 21 ins. and 25 ins. high.

TESTS.—The best economy attained by the Herrick engine in the tests made by Prof. Frederick Pryor, M. Am. Soc. M. E., was 43.8 lbs. of steam per B. HP.-hr. This was with the engine running condensing but with no superheat and was in a test made subsequently to an endurance run of 1,685 hours. The results of the two sets of tests—before and after the endurance run—are shown in Table II.

The following is an extract from Prof. Pryor's report on the tests and endurance run:

Acting under my suggestion, you placed the engine in the plant of the Degnon Contracting Co., foot East 42d St., New York City, and operated it there from August 14 to December 21, 1909. This endurance trial was actual service conditions under ordinary commercial plant conditions. From the time that the engine was started until it was shut down at the end of the run, there elapsed 2,664 hours, including Sundays; or the engine was operating 63% of the full time. During the trial the engine had only four compulsory stops. Of the 979 hours that the engine was idle, only 86 hours were lost due to compulsory stops. The only attention required by the engineers besides starting and stopping the engine was for filling oil cups and lubricators. During the trial the engine operated very satisfactorily, and had the appearance of doing its work for an indefinite time.

After the 1,685-hour endurance run, the engine was again subjected to tests duplicating those on which I reported August 9, 1909. The tests were made under exactly the same conditions as those in the first trial, and the results are comparable.

It will be noted by looking at the appended tables and charts that the engine used less total amount of steam at the same steam pressure and revolutions in its second trial than it did on the first trial. Thus, it would appear that the engine had less leakage after the endurance run than before. There was also however, a decrease in the brake horsepower developed by the engine, and the decreased leakage did not offset exactly the decrease in horsepower, consequently there was a slight increase in the steam consumed per brake horsepower hour.

After these latter tests I had the engine taken apart to ascertain the causes for decrease in steam and power, and upon examination I found that the engine showed signs of rubbing on the revolving parts. This rubbing of surfaces easily explained the decrease of power, and also would explain the decrease in steam leakage. However, the surfaces that had been rubbing were surfaces that should not have been in contact, and were not in contact at the time the engine left for its endurance trial. My explanation of the probable reason for this rubbing contact having developed is that it is probably due to the fact that the bearings were changed during the run. That is, the alinement of the second pair of bearings was probably not perfect.

To sum up the important features shown by my investigation, they are:—

1. The engine ran 1,685 hours out of 2,664 hours.
2. It operated for 66 days of 17 hours each.
3. It operated for 18 days of 24 hours each.
4. It operated consecutively for 149 hours.
5. Only two stops were absolutely necessary due to trouble with the engine, and these troubles were not serious.
6. The total steam consumption of the engine was not increased due to the endurance run.
7. The decrease in horsepower and increase in steam consumed per brake horsepower can be explained by alterations made in the bearings of the engine.
8. The steam consumption of the engine per brake horsepower is exceedingly good for the size of the engine, and it is equivalent to the steam consumption in many engines of equal power now on the market.
9. The space occupied, the weight of the engine and economy of the engine, compared with other engines on the market, indicate to my mind that you now have a commercial engine.

TABLE II. TESTS OF HERRICK ROTARY ENGINE.

Duration of tests, mins.	Steam pressure after throttle, lbs. per sq. in.	Revolutions per min.	Water hour, lbs.	Generator Readings. Volts.	Amperes.	K.W.	Brake horse-power.	Water per hr. per brake horse-power, lbs.
TESTS PRELIMINARY TO ENDURANCE RUN, JULY 29-30, 1909.								
Dry Saturated Steam: Atmospheric Exhaust.								
40	105.3	1,010	782.6	228.06	38.61	8.80	13.38	58.5
40	115.3	1,012	855.4	227.80	45.38	10.33	15.58	54.9
40	125.6	1,007	920.6	228.17	50.19	11.45	17.18	53.6
40	135.2	1,010	979.9	227.80	55.27	12.59	18.82	52.0
40	145.0	1,006	1,039.1	228.67	60.12	13.74	20.48	50.7
Dry Saturated Steam: Exhaust, 18.4 Ins. of Hg.								
40	105.6	1,000	790.9	227.57	51.74	11.77	17.64	44.9
40	115.2	1,012	862.5	227.96	57.36	13.07	19.52	44.2
TESTS SUBSEQUENT TO ENDURANCE RUN, DECEMBER 30-31, 1909.								
Dry Saturated Steam: Atmospheric Exhaust.								
40	105	1,007	728.3	226.22	31.41	7.11	11.30	64.5
40	115	1,017	784.5	228.72	37.04	8.47	13.23	59.3
40	125	1,013	854.3	229.19	42.58	9.76	15.10	56.6
30	135	1,010	934.0	228.50	48.21	11.02	16.95	55.1
40	145	1,010	1,007.3	228.17	54.70	12.48	19.15	52.6
Dry Saturated Steam: Exhause, 19.2 ins. of Hg.								
30	115	1,008	830.0	229.57	53.81	12.36	18.95	43.8
Dry Saturated Steam: Exhaust, Atmospheric. "No Load."								
30	43	1,015	359	.....	....	....	1.5	239.3

The Harriman Rotary Engine.

By CHESTER L. LUCAS* and JOHN J. ROSS.†

The Harriman engine consists of a cylindrical rotor, eccentrically mounted on a straight shaft, working in conjunction with a rocking abutment whose saddle rides upon the rotor. The steam admitted by the inlet valve acts upon the projecting or high side of the rotor, and causes

*4 Bailey Ave., East Saugus, Mass.
†520 Western Ave., Lynn, Mass.

STEAM DISTRIBUTION. — Admission begins when the forward edge of the abutment recess (Fig. 2) passes the lower edge of the steam port and continues until the rear edge of the recess reaches the outer circle of the cylinder wall, when cut-off occurs. Fig. 2 shows the engine in the cut-off position. From this point on, expansion goes on until the piston passes the edges of the exhaust ports. These ports open into the flat sides of the cylinder, one on each side. The edges are given the same shape as that of the piston so as to give a quick opening. There is no compression, nor is any required in a rotary engine. The piston, after exhaust, passes on through the abutment recess to begin the next stroke.

The 20-HP. model tested was so constructed that cut-off occurred at about 1/11th of the working stroke, giving eleven expansions in the cylinder. Simple reciprocating engines commonly cut-off at 1/5 to 1/3 stroke. Possibly the early cut-off in the Herrick engine is partially compensated by the subsequent auxiliary admission of entrapped steam from the abutment recess, which begins at about 2/11 of the working stroke. An indicator card from this engine would be interesting, but none are available.

DIMENSIONS. — The weight of the engine, which is not lagged, is given by the makers as 835 lbs., or about 40 lbs. per horsepower. The engine stands on a base 16 ins. × 4 ins., and occupies a space 17 ins. × 21 ins. and 25 ins. high.

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Acting under my suggestion, you placed the engine in the plant of the Degnon Contracting Co., foot East 42d St., New York City, and operated it there from August 14 to December 21, 1909. This endurance trial was actual service conditions under ordinary commercial plant conditions. From the time that the engine was started until it was shut down at the end of the run, there elapsed 2,664 hours, including Sundays; or the engine was operating 63% of the full time. During the trial the engine had only four compulsory stops. Of the 979 hours that the engine was idle, only 86 hours were lost due to compulsory stops. The only attention required by the engineers besides starting and stopping the engine was for filling oil cups and lubricators. During the trial the engine operated very satisfactorily, and had the appearance of doing its work for an indefinite time.

After the 1,685-hour endurance run, the engine was again subjected to tests duplicating those on which I reported August 9, 1909. The tests were made under exactly the same conditions as those in the first trial, and the results are comparable.

It will be noted by looking at the appended tables and charts that the engine used less total amount of steam at the same steam pressure and revolutions in its second trial than it did on the first trial. Thus, it would appear that the engine had less leakage after the endurance run than before. There was also however, a decrease in the brake horsepower developed by the engine, and the decreased leakage did not offset exactly the decrease in horsepower, consequently there was a slight increase in the steam consumed per brake horsepower hour.

After these latter tests I had the engine taken apart to ascertain the causes for decrease in steam and power, and upon examination I found that the engine showed signs of rubbing on the revolving parts. This rubbing of surfaces easily explained the decrease of power, and also would explain the decrease in steam leakage. However, the surfaces that had been rubbing were surfaces that should not have been in contact, and were not in contact at the time the engine left for its endurance trial. My explanation of the probable reason for this rubbing contact having developed is that it is probably due to the fact that the bearings were changed during the run. That is, the alinement of the second pair of bearings was probably not perfect.

To sum up the important features shown by my investigation, they are:—

1. The engine ran 1,685 hours out of 2,664 hours.
2. It operated for 66 days of 17 hours each.
3. It operated for 18 days of 24 hours each.
4. It operated consecutively for 149 hours.
5. Only two stops were absolutely necessary due to trouble with the engine, and these troubles were not serious.
6. The total steam consumption of the engine was not increased due to the endurance run.
7. The decrease in horsepower and increase in steam consumed per brake horsepower can be explained by alterations made in the bearings of the engine.
8. The steam consumption of the engine per brake horsepower is exceedingly good for the size of the engine, and it is equivalent to the steam consumption in many engines of equal power now on the market.
9. The space occupied, the weight of the engine and economy of the engine, compared with other engines on the market, indicate to my mind that you now have a commercial engine.

The Harriman Rotary Engine.

By CHESTER L. LUCAS* and JOHN J. ROSS.†

The Harriman engine consists of a cylindrical rotor, eccentrically mounted on a straight shaft, working in conjunction with a rocking abutment whose saddle rides upon the rotor. The steam admitted by the inlet valve acts upon the projecting or high side of the rotor, and causes

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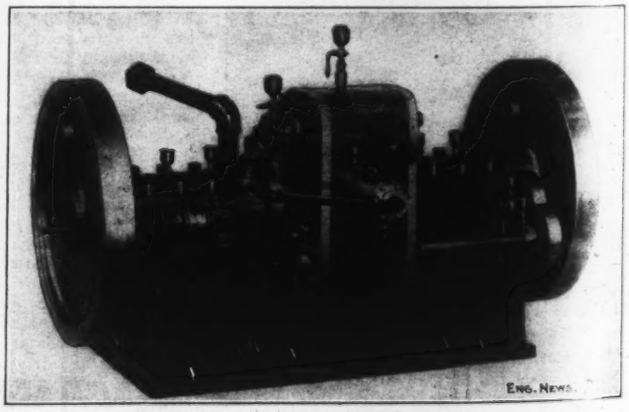

FIG. 6. HARRIMAN ROTARY ENGINE, 25-HP.: LENGTH OF BASE, 40 INS.
(J. Emery Harriman, Jr., Boston, Mass., Inventor.)

the rotor to turn until it uncovers the exhaust port, whereupon the steam is allowed to escape.

The engine shown in Fig. 6 is of the 25-HP. size and is surprisingly simple in appearance and construction. At first glance, the principal parts that the eye takes in are the base, the combined cylinder and steam chest, the remarkably long bearings and the fly-wheels. The absence of valves, rods, cranks, etc., is very noticeable. The compactness of the engine is evident in the illustration. Its size and weight are only about 75% of the weight of a reciprocating engine of like power.

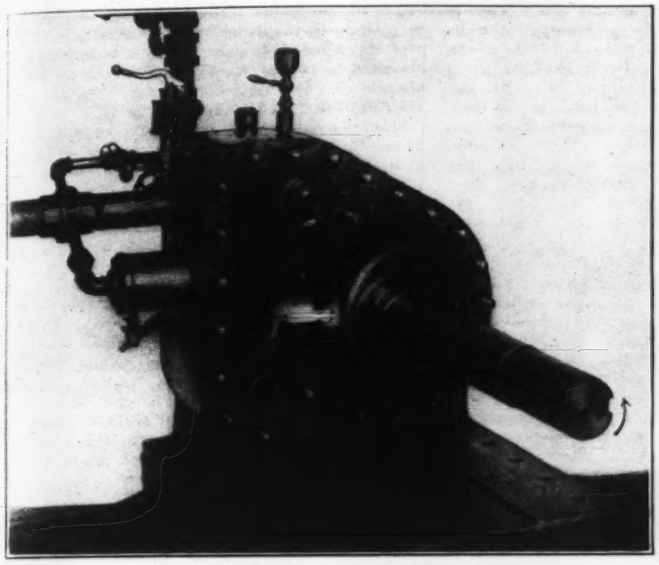

FIG. 7A. POSITION AT CUT-OFF.

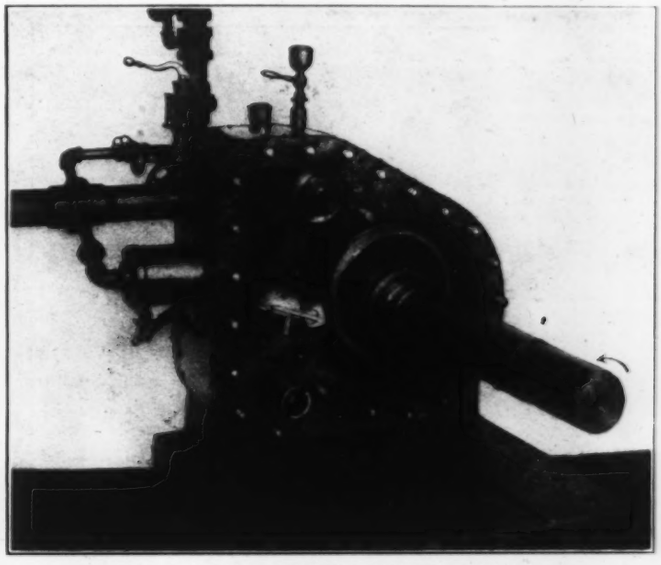

FIG. 7B. POSITION AT BEGINNING OF EXHAUST.

FIG. 7. HARRIMAN ENGINE WITH MAIN BEARING AND CYLINDER COVER REMOVED TO SHOW ROTOR AND ABUTMENT.

As yet there have been no Harriman type engines of large power built, but it is stated that they will be entirely practical, built in any reasonable size. Designs have been made and work is now under way on a 120-HP. rotary steam engine.

The 25-HP. model described was exhibited by the makers, the Harriman Engine Co., 53 State St., Boston, Mass., at the Boston Automobile Show, held in March, 1910. Here the engine was direct-connected to a generator and furnished power for a bank of 100 incandescent lamps.

[The Harriman engine belongs in Class III. (eccentric rotor on shaft central to cylinder) and has a swinging abutment. The main features which distinguish it from other engines of this class are the rotor packing and the device for holding the abutment in contact with the rotor, or piston.—Ed.]

ROTOR, SHAFT AND ABUTMENT.—The rotor, which in this size engine (25 HP.) is 9.4 ins. in diameter and 8 ins. long, is keyed to the 4-in. shaft and is eccentric in relation to the shaft. The shaft is turned down to 3¼ ins. at the parts in the bearings and fly-wheel hubs. In order to balance the rotor on the shaft, large holes are cored out lengthwise through the eccentric side of the rotor, as shown in Fig. 7, and thus most of the weight is removed from the heavy side. At the extreme ends of the shaft, the fly-wheels are keyed on. These are perfectly balanced and one or both may be used as driving pulleys. The shaft passes through the cylinder sides, or heads, with a slight clearance which is made steam-tight by well-designed stuffing-boxes.

Against the outer surfaces of the rotor, operates the saddle which is hinged to and held in place by the rocking abutment. Extending from the abutment toward the left in Fig. 7 is a rod which carries a small piston working in a cylinder communicating with the steam supply. Thus at all times the abutment is pressed against the saddle and the saddle is held against the rotor by steam at boiler pressure and all danger of steam short-circuiting in the cylinder is eliminated. The saddle consists of a plate whose inner surface conforms to the periphery of the rotor, extending across the full length of the rotor. Thus it serves to keep in place the longitudinal packing strip of the piston during its passage across the gap in the cylinder wall.

At the point of greatest eccentricity on the rotor, which is the dividing point between the live and exhaust steam, a slot ½-in. wide and ½-in. deep has been milled. Into this slot is fitted a strip of metal whose outer edge conforms to the outer surface of the rotor. This strip is a sliding fit in its slot, and when the engine is in operation, centrifugal force throws it against the cylinder wall, against which it constantly presses filling the space of .001-in. between the highest point on the rotor and the wall of the cylinder and making it perfectly steam tight.

The construction of the two-way packing rings, one of which is required on each end of the piston, is shown in Fig. 8. Each ring is fitted into a thin shell that covers the inside face and both sides of the ring. The sides of the shell covering have just expansion enough to give packing pressure against the end walls of the cylinder,

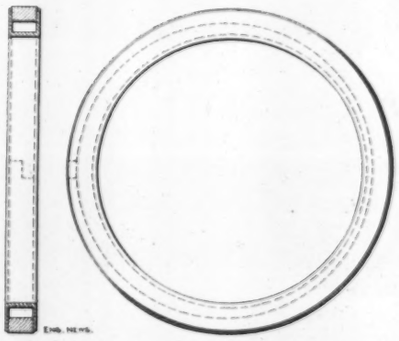

Fig. 8. Two-Way Packing Ring for Rotor of Harriman Engine.

and the ring itself makes a steam-tight contact with the circular slot in the piston end into which it is fitted. Packing strips are also required, as shown in Fig. 7, at the end and sides of the abutment.

CYLINDER, ROTARY ADMISSION VALVE AND GOVERNOR.—The rotor, rocking abutment and saddle are all enclosed within the cylinder casting. The cylinder opening in this casting is 12 ins. in diameter, and just above it is cored out the opening which contains the rocking abutment. Fig. 7 brings out clearly the details of the interior parts. At the point where the lower end of the rocking abutment bears on the main casting, a piece of hardened steel is set in to take up the wear and keep the joint steam tight.

The rotary admission valve, imbedded in the cylinder casting, at the lower left corner in Fig. 7, consists of a tube with two rectangular slots opening through its walls diametrically opposite each other. The inlet port, from the valve chamber through to the cylinder, is of the same shape as the openings in the rotary valve. The exhaust is piped from the chamber that contains the rocking abutment and is of generous size.

The rotary valve is driven by gearing from the main shaft, as shown at the right in Fig. 6, and the valve turns but once while the rotor makes two revolutions, which explains why the valve has two ports. The throttling governor, which is of the Waterman ball type, is belted from a small pulley near one of the fly-wheels.

OPERATION.—From the supply pipe, the steam enters the rotary admission valve shown at the left of the cylinder in Fig. 7. The ports in this valve, are, of course, accurately timed with the rotor, and from the time the valve opens until it reaches the position shown in Fig. 7a, one of these inlet ports is in line with the entrance to the cylinder and the steam rushes in and against the eccentric side of the rotor. This force starts the rotor and it is turned by the direct pressure of the steam until it reaches the position shown in Fig. 7a, at which time the supply of incoming steam is cut off. The packing strip in the rotor, previously described, constitutes the point of separation between the live steam and the expanded steam. The steam pressure behind the rocking abutment is more than sufficient to prevent the incoming steam from passing under the saddle to the exhaust chamber. The fact that the steam enters the cylinder at an entirely different point from the exhaust, is a good point and worthy of noting because the exhaust steam does not get a chance to cool the inlet port.

The rotor, from the position at the time of steam admission, travels one-third of the revolution under direct steam pressure to the position shown in Fig. 7a. At the end of that time, the steam supply is cut off and the expansion of the steam in the cylinder carries it another third of the revolution to the position shown at Fig. 7b, when exhaust is about to begin.

Lubrication is well cared for by means of oil cups as shown in the illustrations. The main bearings have cups and also pockets holding about a pint of oil. The shaft is lubricated by means of a continuous or ring wick which is

much larger in circumference than the shafts and sags down into the oil in the pockets; then as the shaft turns, the wick is carried over with the shaft and supplies the necessary lubricant. Through this process it is necessary to fill the pockets under the main bearings only once a month.

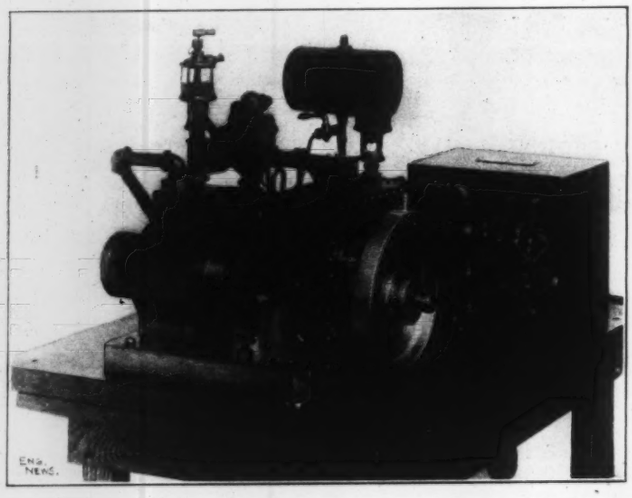

FIG. 9. HARRIMAN ROTARY GASOLINE ENGINE AND COMPRESSOR MOUNTED ON ONE SHAFT.

(The gasoline vapor first enters the compressor, at the left, from which it is supplied to the working cylinder, at the right.)

The engine runs at from 500 to 600 r. p. m. and is practically noiseless and there is no perceptible vibration. This point was illustrated to the writers by balancing a five-cent piece on its edge, on the top of the cylinder. In this position it was left for some time without its equilibrium being disturbed while the engine was running.

TESTS.—At the Massachusetts Institute of Technology, Jan. 12, 1910, Mr. Edward F. Miller, Professor of Steam Engineering, and Mr. T. H. Taft, Instructor in Mechanical Engineering, conducted interesting tests with a 25-HP. engine of the Harriman type shown in Fig. 6. The most important point that was brought out was the small amount of steam consumed per horse-power-hour. Some of the data of these tests are shown in Table I.

ROTARY GAS ENGINE.—These engines are now being built for stationary and marine use and designs for an automobile gas engine are under way, while engines for aerial use are prospective. A gas engine along the same lines as the steam engine has just been completed, and its tests as a model have been so satisfactory that a 25-HP. gas engine is now in process of construction, to be more thoroughly tried out in automobile use.

The working of the rotary gasoline engine and compressor combined is as follows: The gasoline enters a Schebler carburetor, the mixture passes through into the compressor, the high side of the rotor catches up this raw material and compresses it into a reservoir; from this reservoir the motor receives its charge already compressed and at the proper time an electric spark explodes the charge. This explosion creates the power and turns the rotor.

In Fig. 9 is shown the motor and compressor which are on one shaft and whose operation is as above described, but the motor alone will run at a very high speed without the compressor. In the compressor is a single valve which is automatic in its action, while in the motor there is a valve operated by a cam. After the rotor has traversed about two-thirds of a revolution the burned gas entirely escapes and the new charge enters without mixing with the escaping gas. The present motor is water cooled but it is the designer's belief that it can be cooled effectually with air.

The Augustine Rotary Engine.

The Augustine rotary engine has a cylindrical rotor mounted on a shaft central to the rotor but eccentric to the cylinder (Class IV.). The working fluid acts upon a piston blade which moves radially in a slot in the rotor during each revolution. The blade is kept with its outer edge in contact with the cylinder walls by pins projecting from its two ends and carrying curved "cross-heads" which slide in grooves in the cylinder covers.

It is stated by the makers, the Augustine Automatic Rotary Engine Co., 738 Ellicott Square, Buffalo, N. Y., that half-a-dozen or more of these engines, of from 10 to 20 HP., have been put into regular and satisfactory operation driving blowers, etc., and one larger engine, of 100 HP., has been installed at a saw mill. A 45-HP. engine of this type, shown in Fig. 10, is 27 ins. high and stands on a 20 × 24-in. base.

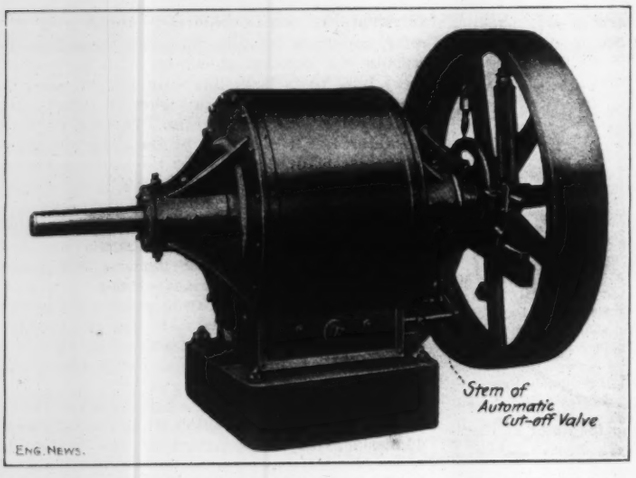

FIG. 10. AUGUSTINE ROTARY ENGINE, 45-HP.: HEIGHT 27 INS., BASE 20 × 24 INS.

(B. F. Augustine, Buffalo, N. Y., Inventor.)

CONSTRUCTION.—The construction of the Augustine rotor is shown in Figs. 12a and 12b. In its assembled form, it consists of a hollow cylindrical cast-iron drum with projecting collars, or flanges, at each end and at mid-length. Each end of the hollow drum is closed by a cast-iron disk. The three flanges really serve as the side walls of two annular cylinders and also serve to support the piston blades when they are extended beyond the body of the rotor.

One of the piston blades is shown in Fig. 12a in position in the slots in the rotor flanges. Each of the two blades is balanced by a counterweight attached to two rods extending inward from the blade across the axis of the rotor. The form of the counterweight is shown in Fig. 11.

The two abutment rings, one of which is shown in Fig. 12c, are of the proper width to fit into the spaces between the flanges on the rotor. When assembled, the outer edges of the rings are even with those of the rotor flanges, and the under side of the body of the rotor is in contact with the inner surface of the rings. The inner face of the ring forms the fourth wall of the annular cylinder space, whose other three walls are formed by the drum and flanges of the rotor itself. The opening through the ring is eccentric to its outer circumference so that the area of cross-section of the cylinder space gradually increases from zero, at the point of contact with the rotor at the bottom, to a maximum at the top. The piston blade is made to travel in a circle concentric with the eccentric opening by means of the curved guide blocks shown in Figs. 11 and 12a, which slide in circular slots in the cylinder cover.

Packing rings around the edges of the eccentric opening (Fig. 12c) are required to prevent leakage between the ring and the rotor flanges. As a further precaution, a "packing block" is placed between the ring and the flanges just below the point of contact of the ring and the rotor drum. This packing block is intended to prevent the passage from the pressure side over to the exhaust side of any possible leakage past the packing ring.

The abutment rings and rotor are enclosed in a plain cylindrical casing, whose two heads, or end covers, contain the roller bearings for the shaft. No stuffing boxes on the shaft are necessary in the Augustine engine. One-half of the rotor drum and one abutment ring are shown in position in the casing in Fig. 13. The shaft journals are made adjustable (see Fig. 11) so that the rotor drum can be brought down to the proper contact with the abutment rings.

The grated exhaust through the abutment ring (Fig. 12c) communicates with that shown in the casing in Fig. 13, which in turn is connected with the exhaust pipe. The cut-off valve is a hollow cylinder turning in a cylindrical chamber near the bottom of the casing. Steam is admitted through slots in the valve to corresponding slots through the walls of its chamber, whence it enters the cylinder through the inlet port in the abutment ring. In Fig. 13 the valve has been pulled out from its working position, to show the ports. The cut-off valve is given an oscillating motion by an eccentric on the engine

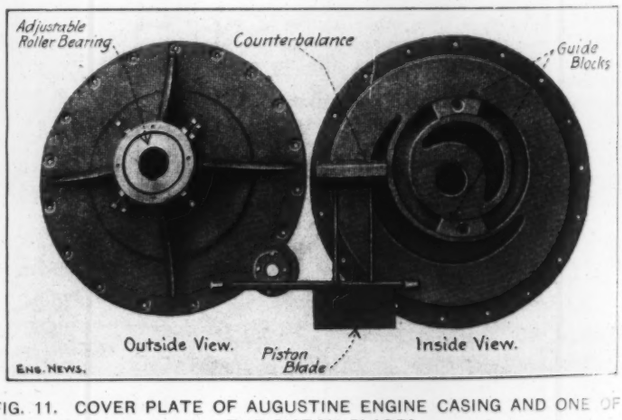

FIG. 11. COVER PLATE OF AUGUSTINE ENGINE CASING AND ONE OF THE PISTON BLADES.

shaft, and the point of cut-off is controlled by a fly-wheel governor.

OPERATION.—The rotor is shown in Fig. 13 in about the position where admission occurs. The contact of the rotor drum with the abutment ring obstructs the escape in that direction of the entering steam, which therefore turns the rotor by pressing against the projecting piston blade. After cut-off, the rotor continues to revolve under the expansive pressure of the steam until the blade passes over the exhaust

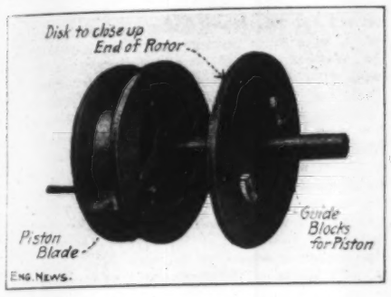

Fig. 12a. One Half of Rotor With End Disk Removed.

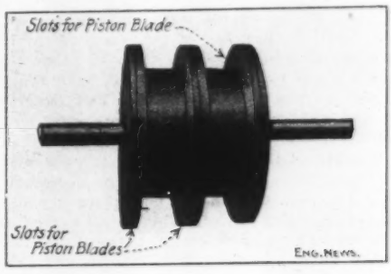

Fig. 12b. Complete Rotor Bolted Together.

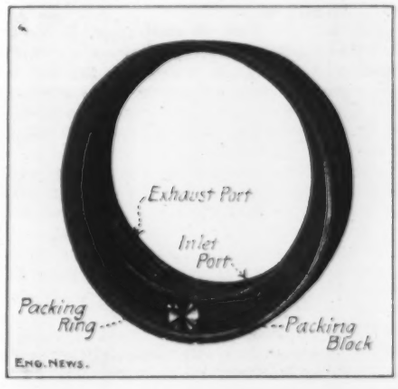

Fig. 12c. Abutment Ring.

FIG. 12. ROTOR AND ABUTMENT RING OF THE AUGUSTINE ENGINE.

valve and the steam is permitted to escape. Revolution continues, under the action of the fly-wheel and of the second piston blade in the other half of the rotor, and the piston passes the point of contact with the abutment ring and is ready for the next stroke. The pistons in the two annular cylinders, separated by the middle flange on the rotor, are diametrically opposite so that both cannot be at the dead-point at the same time.

TESTS.—A 20-HP. Augustine engine was tested by the makers at the factory in March, 1909. No economy tests by a disinterested engineer are available. In the makers' test, the engine was direct-connected to an electric generator. The steam used was condensed and weighed and readings were taken of the steam gage in the supply main and of the voltmeter and ammeter in the generator circuit. In a one-hour run, 631

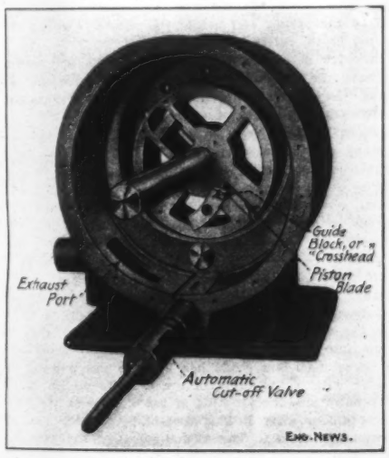

Fig. 13. One Abutment Ring and Half of Rotor in Position in Casing.

(Cover plate of casing and central flange of rotor have been removed. Cut-off valve is pulled out to show its ports.)

lbs. of steam were condensed. The steam gage reading averaged about 99 lbs. The voltmeter showed 110 volts and the ammeter reading averaged about 111. Assuming an efficiency of 85% for the generator, the brake horsepower developed was $\frac{110 \times 111}{.85 \times 746} = 19.3$ B. HP.; and the water rate was $\frac{631}{19.3} = 32.7$ lbs. per B. Hp.-hr.

If the generator efficiency is taken as 90%, the water rate becomes 34.6 lbs.

Improvements and Experiments in Rail Joints.

The rail joint has been a troublesome feature in railway track since the earliest days of railways. Fairly satisfactory designs have been developed and adopted, the vast majority of which are variations of the splice-bar type, with rail ends projecting beyond the joint ties. There is, however, a continuing desire and striving for more efficient and economical methods of supporting and connecting the rails. Four papers on this subject were prepared for the recent meeting of the International Railway Congress by the following writers: Mr. Alexander Ross, Engineer in Chief of the Great Northern Ry., England (whose paper covered both American and British practice); Mr. Chateau, Chief Engineer of the Track and Works Department of the French State Railways; Mr. Blum, of the Prussian Board of Public Works, and Mr. Friedrich Kramer, of the Hungarian State Railway.

From these papers we have compiled the information given below, as of interest to our readers.

Reducing the Number of Joints.

One of the main objects in the introduction of long rails is to reduce the number of joints and consequently the joint troubles. In addition to this, the saving in number will permit of additional expense in strengthening the remaining joints. In this country the length is now usually 33 ft.; longer rails (45 ft. and 60 ft.) have been used. The New York Central Ry. reports that 45-ft. rails were unsatisfactory, on account of the fact that it was not possible to give them as good a surface finish at the mills.

In Great Britain, a few railways use 30-ft., and a very few use 60-ft. rails. A large number use 45-ft., and this is looked upon as the standard length for the future. In France and Belgium the length is from 54 ft. 2 ins. to 78 ft. 9 ins.; the usual length, however, is 59 ft., but three railways have adopted 72 ft. 2 ins. as standard. For renewals in case of failure, three short rails are used, being distributed at local storehouses. Mr. Chateau predicts a further increase in length, but admits that this will necessitate an entire change in joint design. A frictionless joint without bolts is his suggestion.

In Germany, the usual lengths are 29 ft. 6 ins. to 49 ft. 3 ins. Rails 59 ft. long are used in tunnels, on bridges and at road crossings. In Austria and Hungary the maximum lengths are 41 ft. to 49 ft. 3 ins.

Present Types of Joints.

UNITED STATES.—In this country, the suspended type of spliced joint is used to a much greater extent than any other, although the "bridge" type (which affords a continuous base support resting on the shoulder ties) is very largely used. The report by Mr. Ross (of England) covers the United States, but is erroneous in stating that "the type of joint used is almost universally the bridged joint, very few companies using supported or suspended joints." It is true that supported joints are little used, but there are few railways which have not a large mileage of suspended joints. The error is due, probably, to the fact that individual railways report the use of bridge joints, without giving the relative mileages of these and other types. In several cases they are used only to a comparatively small extent, while it appears also that some of the special joints included as "bridge" do not belong to that type.

The Pennsylvania Lines report unsatisfactory results from tests of six different joints: three of these are experimental devices, one is the miter joint (with rail ends cut diagonally), and two are in very extensive use.

GREAT BRITAIN.—The joints are almost universally of the suspended type, except where old tracks with supported joints have not yet been relaid. Most railways have tried to improve the joints by closer tie spacing, by special supporting chairs (for double-head rails), and by special splice bars. In some cases the chairs on the joint ties have the rail seats extended so as to leave the rails unsupported only for a distance of 13½ ins. In a few cases the two chairs are connected by a rail-supporting bridge which is cast integral with them or fitted as a separate piece.

FRANCE AND BELGIUM.—Suspended joints are used in a majority of cases, with four-bolt angle splice bars of various patterns. Many of these bars are of Z-section, being reinforced or made more rigid by a vertical web which projects below the rail base. In view of the long life of steel rails (estimated at 100 years with a wear of 0.039-in. per 100,000 trains), special attention is now being given to the improvement of the joints, as rail renewals are made usually on account of deflection at the ends. Bridge plates have been tried in a few cases, but without satisfactory results.

GERMANY.—Within the past few years all the government railway administrations have endeavored to reinforce the rail joints by strengthening the splice bars and (with suspended joints) by reducing the distance between the shoulder ties. This distance was formerly 23½ to 27½ ins. c. to c., but is now 13 to 15¾ ins. With this spacing it is still possible to tamp these ties properly, but it is suggested that with one very wide tie to distribute the load the ballast would not require so much tamping. This idea has been carried out by some lines, which place under the joint two ties which are in contact and are united by metal dowels so as to act as one piece. As the upper corners of the ties are bevelled, however, the rail ends are still unsupported for a few inches, except where a long base-plate bridges this gap. Even a double-width steel tie for supported joints is made with a corrugation along the middle.

In general, suspended four-bolt joints are used, the splice bars often extending below the rail. In some cases, however, the outer bar is reinforced by an upper rib (which lies against the rail head) or by a wide horizontal top flange. In bridge joints, the bridge plate has (like the tie-plates) a hooked rib on one side to fit over the rail flanges, while the other side is bolted to the flanges. Independent of these bolt fastenings are the screw spikes which hold the bridge plate to the shoulder ties. The so-called American three-tie supported joint with long six-bolt splice bars (now little used in America), however, has been tried, but without satisfactory results.

AUSTRIA-HUNGARY. — In improving the joints for use in connection with the new rails of greater length and weight the general practice has been to increase the length of the splice bars and to use six-bolts instead of four. This change in practice is strange in view of the general tendency to the use of short splice bars in other countries. It seems, however, that the change has not been satisfactory as it has resulted in many fractured splices, and for this reason one railway has returned to the four-bolt type. The two bars are usually of the same section, and some are 35½ ins. long. The best improvement is considered to be in a closer spacing of the ties.

A special feature of the new joints is the strengthening of the fastenings at the shoulder ties, in order to hold the rail rigidly upon these ties and prevent any vertical movement of the rail relatively to the tie. The tie-plates or base plates on these ties are very much heavier than those on the intermediate ties. They have recesses for the countersunk heads of bolts by which the rail is bolted firmly to the plate. Each plate has two of these rail bolts, and three screw spikes to secure the plate upon the tie. Bridge plates are said to have been tried, but without successful results.

Adjusting Damaged Joints.

In many cases rails are damaged only at the ends, and the improvement of such rails by cropping the ends and re-drilling them for the splices has been tried at different times by railways in this country. The Pennsylvania Lines report that in 1897 and 1898 several rail-sawing plants were established for this purpose, but the cost was excessive as compared with the results and the practice was discontinued.

This practice has been followed in France by the Northern Ry. and the Western Ry. The latter road also straightened the rails, which were found to have a regular vertical curvature from end to end. The straightening can be done on the track by a gang of men trained for the work. It should be done preferably in summer.

To compensate for the wear of the fishing or contact surfaces of the rails and splice bars, it is a very general practice in Europe to insert thin shims of hoop iron. (Eng. News, July 23, 1908.) Mr. Chateau (France) in his paper states that while this often is done it is only a partial remedy and not a cure. It may, in fact, induce the fracture of the worn splice bars due to the stresses caused by this adjustment.

Welded Rail Joints.

The application of the welding process for the elimination of rail joints has been tried to only a small extent on steam railways. The results are not promising, either as to construction or maintenance. In France, a few experiments have been made in order to reduce the number of joints on old short rails and to eliminate rail joints on long bridges. The joints, however, were deficient in strength, and the rails were likely to be brittle at the joint, due to chemical changes which result from the heating of the metal. Both the Goldschmidt thermit and Falk cast-weld systems were used, but the results were not as encouraging as those obtained on street railways. Mr. Blum states that German railways have no experience in this direction. He considers that at high temperatures excessive stresses would be produced in welded rails on open track (not embedded in paving). These would result in deformations, dangerous to traffic.

More definite results are reported by Mr. Kramer (Hungary). In 1904 and 1907, when heavier (97-lb.) rails were laid on the open line, the old rails (67 and 69½-lb.) were left in place at stations, the ties being spaced more closely to give sufficient strength to the track. Breakages of the stepped or cranked splice bars connecting the new and old rails were so numerous that thermit welding was tried as being possibly economical in spite of its first cost. The strength may be reduced by the process, but this may be compensated for by the increased amount of metal. Tests were made with the thermit process at the shops, and as a result 198 of these welded step-joints were laid in the track. Only one of these failed. In 1904 and 1907 eight tests were made with welding rails of uniform size to form continuous lengths of 156½ to 592 ft. Both 67-lb. and 86-lb. rails were used. The ends were spliced with six-bolt bars, leaving wide expansion openings. In all, 320 welds were made (thermit process).

Only three fractures occurred: two of these being in 157 ft. lengths of continuous rail; (1) the additional metal broke away, together with the flange and web of rail; (2) the rail cracked for a length of 8⅜ ins. near the weld, and was repaired by welding in a piece of rail 6½ ft. long; (3) one of the welded step joints separated at the weld. In addition, at two welds in the long rail lengths and at four of the step joints there was a slight separation at the rail head (3-64 to 5-64-in.). The weld at the web and flange remained unaffected and these joints were left in place.

It is stated that with fractures in rails welded into continuous lengths it would be necessary to take out the entire length and replace it with ordinary rails and splices. This would not be difficult for lengths up to 100 ft., but with lengths of 300 to 600 ft. it would be so difficult and expensive as to be impracticable under ordinary conditions. The general use of long welded sections of rail would be practicable only if the fracture could be re-welded in the track (and by the regular maintenance gangs), without causing too much interference with traffic. Quickness and simplicity are essentials, but neither the Falk nor thermit systems are considered as meeting these conditions. In many cases, also, it would be necessary to saw pieces from both sides of the fracture and weld in a piece of rail to fill the gap. Mr. Kramer's conclusion is that rail welding can be made applicable to main line track only in the event of improvements in present processes or the invention of some new welding process making it possible to do the work much more quickly.

Welded lap joints have been tried on the Mecklenburg State Ry. These are said to have given good results, but they have been in use too short a time for any definite conclusions to be drawn.

Special Joints.

In nearly every country experiments have been made with special forms of joints, a few of which may be noted here. The Great Northern Ry. of Ireland places a tie longitudinally under each joint, the ties being connected by a tie-rod. This is said to be satisfactory. Some French railways are using the boltless wedge joint illustrated in our issue of May 27, 1909. The Gothard Ry. and the Baden Ry. have tried a joint with deep splice bars, slotted in the lower webs to receive a cross piece forced up against the rail base by a wedge. This led to fractures of rails at the bolt holes, and has been modified on the latter road by using two of these wedged supports, one under each rail end.

Two German joints are the Melaun and the Bochum. The former has each rail head cut away for a few inches, the gap being filled by a hollow saddle piece which rests on the webs and flanges of the rails and has its flanges bolted to a base plate. The Bochum joint has deep splice bars so shaped that the lower webs support a bridge plate; the bearing surfaces are inclined, so that screwing up the bolts (under the rail) forces the bridge plate tightly against the rails. Mr. Blum states that extensive trials have been made on German railways with different forms of lapped or scarfed joints, and with wheel-bearing splice bars. The former have given varying results. Of the latter, those in which the rail-carrying bar does not act as a splice have not been satisfactory, but better results have been obtained with the Neumann joint, in which the outer splice bar has an upper rib which fits against the rail head and carries the wheels for nearly the entire length of the splice.

THE FOREST AREA OF THE RUSSIAN EMPIRE is given in "Monthly Consular and Trade Reports" for June, 1910, as 549,800,000 acres, of which 65% is owned by the Russian Government. In 1907 the state forests yielded about 154,000,000 M. ft. B. M. of lumber, but it is stated that reforestation of state lands provides for more than the amount cut each year.

Construction and Maintenance of Park Roads.*

By JOHN R. RABLIN.†

The roadways constructed under the direction and supervision of the writer in the development of the Metropolitan Park System of Boston, Mass., have been for the most part roads which were to be subject only to pleasure traffic—i. e., light horse-drawn vehicles and automobiles. In the construction of these roads trap rock or other hard rock was generally used. As soon became evident, however, even before the automobile was used to great extent, that this type of road surface was not well suited to the class of traffic which used it, as a large percentage of the pleasure vehicles were equipped with rubber tires, and there was not enough wear upon the stone to supply the binder necessary to keep the roads in good condition. The sections of road constructed with the softer grades of stone were much more easily maintained in good condition and the actual wearing away of the surface was slight. With the advent of the automobile the stripping of the surface of the macadam roads, especially those constructed with the harder grades of stone, immediately became so rapid that it was necessary to adopt other methods of construction than that of the ordinary macadam.

Some gravel-surfaced roads were constructed during the early stages of the development of the system, and these proved to be much better suited to the light traffic than macadam. They were better for horse driving, less affected by automobiles, and more easily repaired. During the last six or seven years, this type of road has been built almost exclusively for these parkway drives.

They have been built with special care in the selection of materials and in the workmanship. Where possible it has been the practice to obtain material composed of sharp, angular stones with only sufficient clay properly to bind the stone. In some cases it has been necessary to use a clean, sandy gravel and add a clay binder during the process of construction, which method is generally not as satisfactory as when the material is in the proper proportions in its natural state. The surfacing material is 8 ins. in depth, and is laid in two 4-in. layers, and each layer is thoroughly compacted by the use of sectional-grooved rollers drawn by horses. All stones larger than 1½ ins. in diameter are screened out, or in cases where the material in the bank contains but little stone larger than this size the larger stones are raked out after the gravel has been spread upon the road.

The principal objection to this type of road is that at the season of the year when the frost is coming out it is likely to rut if the amount of clay binder is at all excessive. This condition lasts only for a short time, and the road surface is easily and cheaply smoothed out if the work is done immediately after the frost is out in the spring and before the surface becomes compacted in its rutted condition.

In order to overcome this objection and still continue to have the gravel-surfaced type of roads for the parkways, the writer has been for the last two years using a crushed stone base of about 4 ins. in thickness with a 2½-in. to 3-in. layer of binding gravel on top. This method provides good drainage and a good base for the gravel surface. After the completion of the surface, and before it has become too hard readily to absorb the material, a treatment of heavy asphaltic oil is applied, which serves to make it dustless and in a large measure to preserve it. About 1 gal. of oil to the square yard is required.

In some instances where it was necessary to allow heavy traffic on the parkway double roadways are constructed, one roadway being built with macadam for the use of this traffic. Since the automobile has come into general use the practice in the construction of these macadam roads has been to use a bituminous binder with a top layer of stone. The method is that of penetration—the grouting of the stone with the bituminous binder after it has been laid upon the road and thoroughly rolled. The bituminous material is applied at a temperature of from 150 to 200° F., and sufficient is used to fill the voids near the surface, usually about 1½ gals. per sq. yd. After the application of this material the surface is again thoroughly rolled and a flush coating of bituminous material is applied by brooming or spraying, the surface being afterwards covered with clean, sharp stone screenings, and again rolled. This forms a gritty, well-bonded surface, which has proved very satisfactory.

The bituminous material used in the work on the parkway roads has generally been a refined coal tar for the first application, and a mixture of refined tar and 10% residual asphalt for the flush or painting coat. The object of the asphalt is to give life to the surface and prevent its becoming hard and brittle, and therefore slippery. This percentage of asphalt is too small to be of much advantage over straight tar, and the use of clear asphalt for this class of work is advisable even at an increased cost.

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In view of the fact that the rotary engine, pet theme of inventors, has never been able to win a place in commercial practice, a word of explanation may be due for the space given to it elsewhere in this issue. The simple fact is that efficient performance is always worthy of recognition, and when the rotary engine, as in the tests reported, produces power at about the same steam-rate as reciprocating engines of equal capacity the fact merits some attention. Of course this performance does not answer for that of larger units. But, so far as they go, the present results are distinctly ahead of previous records for rotary engines, and this gives interest to a general review of recent developments.

The rotary engine is old. No new invention is required to make a rotary that will run, even run smoothly and at high speed. The great difficulty has been to prevent excessive and wasteful steam leakage. The problem of designing an engine of this type which can be satisfactorily packed without increasing the friction beyond all reason is a most difficult one, upon which, in fact, a vast amount of fruitless labor has already been wasted. But in addition, a suitable design to solve the leakage difficulty must have regard to the necessities of economical manufacture. In the attempt to produce models in which undue leakage could be avoided, many inventors have evolved designs the manufacture of which on a commercial basis would be out of the question.

It is important to note that the engines of which the more successful tests have been reported are all of low horsepower. In fact, the great majority of the rotary engines ever actually built and tested have been less than 30 HP., and it is safe to say that no rotary engine unit has ever been built of as much as 150 HP. Until much larger units have been built, and proved successful both in test and in practice, there will be no large field for the rotary engine. For the relative success of a rotary of 25 HP. would by no means insure the equivalent success of a 1,000-HP. unit. It is even altogether possible that, in building larger rotaries, unsurmountable difficulties might arise to cut down efficiency or raise unduly the cost of manufacture. Tests upon larger models, of 100 to 150 HP., which are reported to be already under construction, will be interesting.

Perhaps many of the multitudinous past failures have been due in large part to the limited qualifications of the experimenters. The great majority of rotary engine "inventors" have undoubtedly been quite devoid of any adequate training or experience in steam engineering. With this in mind, it is not too much to expect that the intelligent application of established principles, coupled with the gradual development of suitable machine-shop methods to meet the rotary's peculiar needs, may eventually raise to a more reputable standing this discredited type of prime mover, classed at present with perpetual motion machines and other mechanical absurdities.

In the northern part of New York State, fortunately well out in the country and far removed from any critical eye, except that of the rapidly passing railway passenger, there is a concrete bridge of some seven or eight spans which for general unsightliness has a distinction all its own. Its lines are not at all bad, and its decorative features are well within the limits of conventional design, but the finish of the surface is so decidedly unattractive as to make that ugliness the most observed feature of the structure. This finish is the ordinary plaster coating, so common a dozen years ago when the bridge was built, but in the lapse of time patches have dropped out, cracks and crazes have appeared, and water has percolated through carrying the disfiguring efflorescent streaks until now the surface resembles nothing so much as a whitewashed barn some five years after its initial coating. In contrast to this bridge there is in a park outside the city of Philadelphia another massive concrete arch where the most modern of surface treatments has produced a uniform, rock-like, glittering surface that adds measurably to the beautiful lines of the bridge.

The difference between the two bridges is just the difference between the Library of Congress at Washington and an old New England cotton mill. Structurally one of these buildings serves its purpose equally as well as the other but the mill is purely utilitarian while the Library is a source of pleasure to all who view it. So also the vital difference between the two bridges is not in the structure, though the twelve years advance in engineering science may have added somewhat to the Philadelphia arch; the point of superiority is in the surface treatment, in the manner of preparing or treating that portion of the bridge that meets the eye.

Concrete as a new building material had to satisfy equally the two requirements of strength and of beauty. The former of these is now admitted by all to be possible if simple, easily-learned rules of manufacture and design are honestly followed. The latter requirement, that of beauty, is not so easily procurable nor are the methods by which it is secured so readily reduced to verbal description. Beauty in concrete design is a matter of grace of line, shade and shadow, and texture and color of surface finish. The securing of these artistic qualities is the function of the architect rather than the engineer. Some engineers can acquire them and some can never hope to do so. Such acquirement, when possible, can result only through close and long-continued study of the best models or examples afforded by art and painstaking attempts to put the teachings of such studies into actual form and surface.

The art of graceful design is so distinctly personal that we can hardly expect it to be made the subject of professional discussion, though doubtless such discussion can be found in the literature of art. Only to a lesser degree can the same be said of the science of making a desirable concrete surface, for this latter has in it enough of the artisan as distinguished from the artist to make its processes a matter of record. Nevertheless, the subject of concrete surfaces has been insufficiently touched upon in the voluminous literature of the subject and it is for that reason that we desire to call attention to the report of the Committee on Exterior Treatment of Concrete Surfaces of the National Association of Cement Users, which we reprint on another page of this issue. In as far as the experience of a number of men can be recorded for the benefit of the profession at large the committee has done its work very well and has helped materially to fill a void in the literature of concrete. We could wish that more space had been given to costs, for it is upon this item that the manner of treating surfaces most often turns, but aside from this lack we think that the report of Mr. Wason's committee will be much appreciated by all concrete users.

In another part of this issue, an American engineer, traveling abroad, describes the very interesting studies conducted in the laboratories of The Sorbonne at Paris looking to the commercial disinfection or even sterilization of water for domestic supplies. The experimenters evidently believe in the practicability of a commercial process based on their very significant results, and it is not improbable that a few years or months hence we may hear of a plant intended to rival the ozone processes so evidently popular abroad. Therefore, it is interesting to make a few brief comparisons of the data in Mr. Grant's article with those on ozone processes in Engineering News, of April 28, 1910.

In the first place, Mr. Grant places the cost of energy delivered to the mercury-arc lamps at about $1.40 per 1,000,000 gals. of water treated. The most efficient ozone generator we know of would require about 30 KW.-hrs. per 1,000,000 gals., using the approved mixture of about 1 gram of ozone per cubic meter of water. This, at Mr. Grant's 1 ct. per KW.-hr. for electricity, would cost 30 cts., compared with $1.40 for the ultra-violet light scheme. In the various ozone processes, the cost of producing the ozone is but a small factor of the whole cost of treating the water supply, some 60 to 70% of that total cost, being distributed about the auxiliaries necessary to secure a contact between the water and gas. Similar conditions will prevail in the ultra-violet light exposure for the penetration of the bactericidal radiations is not far beneath the surface of even clear water. There is the same need of prefiltering where objectionable color is given by suspended particles. The one merit which seems to be prominent in this use of ultra-violet rays lies in the rather simpler and less expensive apparatus required.

The absurd restrictions on the use of the Forest Preserve of New York State, inserted in the constitution at its last general revision have been condemned in these columns more than once. There is now a fair chance of a slight lessening of these restrictions through a constitutional amendment, for the Legislature has already passed a concurrent resolution to that end once, so the question will come up automatically at the next session. Presumably the question must go to popular vote after that. By 1911 or 1912 there is reason to hope that popular enlightenment will have reached such a state that the people will see that there is a higher use of the Forest Preserve than keeping every acre of it forever as "wild forest lands."

For our present purposes the essential part of the proposed amendment is as follows (the portion in italics):

Section 1. Article 7. The lands of the state, now owned or hereafter acquired, constituting the forest preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed. *But the Legislature may provide by general laws for the construction and maintenance of reservoirs under state control on such lands whenever the storage of water is necessary for municipal water supply, for the canals of the state or to regulate the flow of streams.* [The resolution goes on to provide for public hearings, court review, etc., in connection with setting aside land for the

purpose indicated; and for payment to the state for lands so taken, except for canal purposes.—Ed.]

It is a pity that the proposed amendment does not go farther and permit the State to handle its Forest Preserve in accordance with forest principles. As the language of the constitution is now interpreted, the State cannot even remove and sell dead timber, to say nothing about making improvement cuttings. This is Conservation with a vengeance. As a matter of fact, the prohibition in question was made with no idea of conserving natural resources but merely to keep wild and inaccessible lands wild and inaccessible. It even bars the construction of roads through the Forest Preserve.

Fortunately there will be another general revision of the constitution of New York before many years. It is to be hoped that a more sane and common sense view of the Forest Preserve will then be taken, and the constitution amended accordingly. Meanwhile, there will be some gain, even though relatively small, if the State gains power to construct reservoirs for its own and the public good on land which it has acquired at great cost.

Does it take five men working for a city to do as much work as one working for a private employer? We have it straight from a man who ought to know that it does, as may be seen from the brief article on a School of Municipal Accounting, printed elsewhere in this issue. Mr. Herman A. Metz, as manufacturer, has been checked against the same man as Ex-Comptroller of New York City, with the result indicated. Due to this finding and for various other good reasons Mr. Metz has set aside $30,000, to be used by the Bureau of Municipal Research of New York City to conduct a correspondence school in municipal accounts and reports, open, it appears, to the whole country. The deed is a commendable one. It might well be emulated in some other hitherto neglected municipal fields.

The Completion of the Pennsylvania's New York Extension.

It is hardly open to doubt that among indirect improvements, i. e., such as do not produce revenue directly, the great Pennsylvania terminal extension to New York City is far and away the most costly and elaborate ever undertaken by private enterprise. In this respect if in no other the work is a lasting monument to the ability and courage of the man who brought it into being. Other men might have conceived the project as a constructional possibility, and might have become enthusiastic over its attractive aspect; but facing the expenditure of a hundred million dollars for a local improvement of passenger facilities already satisfactory, and realizing that there would be small likelihood of collecting a higher fare for the better service, they would have turned away from the thought as from a beautiful delusion. Only a phenomenal degree of farseeing judgment, and equally phenomenal courage, could have produced the determination to plunge into this abyss of expenditure. The late President A. J. Cassatt has immortalized himself in the now-completed work with these qualities.

It may be years before Mr. Cassatt's judgment will see itself vindicated by the net showing of the railway company's balance-sheet. But in the meantime no one acquainted with the railway and transit situation in New York and with the city itself can fail to recognize the admirable adaptation of the great improvement to the requirements of the immediate as well as the more distant future. Large cities everywhere are presenting in very direct form the question whether the railway should land its passengers in a central region or should end in an outer zone, or at least some distance away from the most congested and therefore most valuable area. The question at large has not yet been answered, and may not be for a long time to come. The traveler's preference, however, is obvious enough, and his patronage of the most central terminal is bound to have its influence on the railway manager.

In providing central facilities, however, it is ultimately the city's interest, the interest of the traveling public, that is served. The value to the railway which provides such facilities is only the resulting competitive preference, and when competitors have made similar provision there will be no special returns upon the investment for any of the lines. Ultimately the traveler must pay the interest, and very likely the traveler along the line as well as the one who uses the terminal. But the real gainer is the city which has the terminals. Obviously, then, it should take a share in bearing the special burden of cost. The least it can do is to make its conditions as easy as possible, and, if not furnish the land needed, at least set its taxes, easement rentals and the like at a minimum figure.

The importance of the engineering operations composing the Pennsylvania terminal works warrants the belief that every student of technical matters will read and keep on file the compendious description published under the aegis of the American Society of Civil Engineers, in sixteen or more separate papers written by the engineers in charge of design and construction. But a short guide or index to this exhaustive treatise will be needed by many, and to meet this want we have prepared an abstract of data, as brief as possible consistent with defining the main structural elements and essential operations. To this we have prefaced in a few paragraphs a suggestive sketch of the history of development of the project; both description and history, of course, were based on the papers mentioned. That our summary itself extends to some ten or twelve thousand words is a reflex of the complexity and difficult nature of the work.

Two points in the general aspect of the work are specially commended to the reader's notice. First, it was carried out in remarkably short time. About two years sufficed for elaborating designs, and construction took less than seven years. These are surprisingly short periods, not merely because the work was very large but because much of it was very difficult. A line less than fourteen miles long cost about $7,000,000 per mile, and even if the terminal station and yard be deducted this figure would still be in the neighborhood of $6,000,000; it is a fair index of the difficulties which had to be overcome. As a comparable enterprise nearby we have the Interborough rapid-transit subway in New York: Of about the same total length, this line cost only half as much per mile of line, and per mile of track probably only a quarter to a third as much, as the Pennsylvania work. It took nearly as long to build, in spite of the fact that its nature permitted attacking it in some twenty sections as compared with seven in the case of the Pennsylvania. The latter comparison, containing an expression of the distribution of difficulty over long unit stretches, brings out fairly the rapidity of construction which marked the Pennsylvania work. There is ground for supposing, moreover, that special straining for early completion could have cut down the period of six and a half years by a respectable fraction.

Second, the work was put through in exceptionally smooth and harmonious fashion. Differences among contractors or between employing company and contractor were notably scanty. The design plans proved themselves complete and adequate to a gratifying degree, despite the serious unknown difficulties which were met in construction. Yet their administration was flexible enough to permit of changes where physical conditions demanded. Coordinately, the work done was accurate and excellent, and few accidents and but a small part of the damage and loss of life which might reasonably be expected had to be recorded. These facts are not only creditable to the contractors but even more strongly testify to the value of thorough, well-managed organization of the engineering forces. An indication of the part played by this element is to be found in the short time required for preparing designs, which to us is distinctly more notable even than the rapidity of the subsequent construction.

The Continued Legislative Defeat o[f] More Stringent Control Over Sewage Dis[posa]l in New York State.

Judging by the standards of ten years [ago] the New York State Department of Health [already] has a considerable degree of control over [the in]stallation and extension of sewerage syst[ems] and the general question of sewage and trade [wastes] disposal and water pollution within the [State]. But progress in these lines has been mar[ked] in some of the other states of late, notably the neighboring states of Pennsylvania and O[hio] so that while New York is still far in advance of the majority of the states of the Union, it is far in the rear of a few in its control of the purity of the waters of the State.

At two successive sessions of the New York Legislature, bills have been defeated which were designed to give the State Department of Health full control of the sewage disposal and water pollution situation. In 1909 a bill to this end was passed by the House but did not come to a vote in the Senate, and in the present year a similar bill was defeated in the Senate by a vote of 25 to 19. This defeat occurred twice in succession, notwithstanding the perfectly legitimate efforts of the State Department of Health to impress upon the public the need for additional legislation, and in spite of strong efforts made by unofficial would-be conservators of the public waters of the State. Since the campaign against water pollution in New York State is bound to be continued and since a similar campaign is already under way, or will soon be taken up, in many other states, it seems worth while to ask why the proposed New York legislation has twice come to defeat. We are not sure that we can give a satisfactory answer, but we can at least attempt to lay the matter before our readers for their possible answer; or at least for their consideration, in connection with future campaigns of the kind in New York or elsewhere. Let us first gain an idea of the character of the proposed legislation, which, it should be added, was in the nature of amendments to the existing law giving the State Department of Health some measure of control over sewage disposal and water pollution.

The New York law already prohibited the discharge of sewage, garbage, dead animals, or decomposable and putrescible matter of any kind, as also chemicals or waste matters, into any of the waters of the state, except on written permission from the State Commissioner of Health. The law was not applicable to public sewerage systems or to trade wastes outlets in existence prior to May 7, 1903, but it did more or less directly give the Commissioner control of such existing sewerage systems or trade wastes outlets, provided material changes were made in construction or the quantities of wastes discharged were materially increased.

Under the proposed amending legislation of 1910, it was designed to make the qualifying clause "in quantities dangerous to the public health" applicable without question to all classes of wastes discharged into public waters which might be deleterious to the public health, and also to leave no question as to the necessity of obtaining the consent of the Commissioner before it would be lawful to discharge effluents from either municipal or industrial sewage or trade wastes purification plants into the waters of the State. In addition, and far more significant, the amending legislation was intended to give the Commissioner full authority to prohibit the discharge of sewage or any kind of polluting municipal or trade wastes into any of the waters within or around the boundaries of the State, when, in the opinion of the Commissioner, such discharge would result in pollution which would be injurious to or a menace to the public health or create a public nuisance. Provision was made for issuing orders to any municipality, corporation or person involved to show cause why such a discharge should not be discontinued. After a stated hearing of all parties interested, the Commissioner would have had authority, had the bill passed, to order the co[n]

sation of the discharge and such method of treatment or disposal of the sewage or waste matters in question as would, in the opinion of the Commissioner, obviate such pollution. Such orders, however, were not to be valid until approved by the Governor and Attorney-General of the State. When so approved it was made the duty of the Attorney-General to enforce the orders. The Commissioner was also authorized to set a date for compliance with the order and to insist upon "certain definite progress" being made "at certain definite times prior to the final date fixed in the order."

Furthermore, and of great possible benefit to the comfort and health of citizens of the State, the proposed Act contained a section giving the Commissioner control over the operation of sewage purification works, to the end of ensuring better operating results whenever such were demanded by the public good.

Other amendments to the Act were designed to give the Commissioner more complete control over the plans for new, remodeled, or extended sewers and sewage disposal systems, approval of which must now be secured from the Commissioner before construction can be begun. Finally, we note that one of the changes proposed in the existing Act directed the Commissioner to bring action in the name of the people of the State against violators of any provision of the Act as amended, for the recovery of any penalty incurred by such violation, and also for an injunction against a continuance of the violation.

Those familiar with legislation upon this general subject will understand from the foregoing outline of the proposed new legislation that if it had been enacted, it would have given the New York State Department of Health substantially the same authority over sewage disposal and water pollution as is now exercised by a similar department in Pennsylvania, by the Ohio State Board of Health and also by one or two other states.

From a broad public viewpoint there can be little, if any, question as to both the need and the wisdom of legislation of just this sort for every state in the Union. Objections to state legislation, in so far as they exist, must be based chiefly on local and private grounds; that is to say, they must come either from municipalities, individuals or corporations who wish to be free from state control in order that they may avoid expense and trouble, even though it be to the detriment of the public.

It is true that some have urged that the proposed new legislation vested too much power in the Commissioner of Health. It should be noted, however, that the Commissioner alone is not authorized to require changes in sewerage or sewage disposal systems built prior to the date that the original Act went into effect, but that to be valid orders for such changes must also be approved by the Governor and the Attorney-General, each of whom might be expected to be thoroughly representative of both the local and state interests involved.

We suspect that the strongest and most effective opposition to this legislation came from the manufacturing interests, and particularly those behind the paper and pulp industries, although there is little question but that strong opposition may have come from some of the municipalities of the State.

The continued defeat of this legislation will doubtless have a sobering effect upon both the State Department of Health and some of the unofficial would-be conservators of the purity of the waters of the State. The continued defeat indicates that all concerned in the prevention of stream pollution must have a care lest they attempt to go faster than public opinion warrants. Water pollution may undoubtedly be a serious nuisance and a possible grave menace to public health. At the same time, it is far easier to declare that it must be stopped than it is to provide ways and means of stopping it without injury to some industries, or without crippling municipal activities in directions which are perhaps far more important to the public convenience and health than are the improved means of sewage disposal.

Municipalities in some of the states which have entered upon vigorous campaigns against water pollution have some reason to feel that they are in danger of being called upon to do more in the way of sewage treatment than is warranted by either sanitation or economics, especially in view of the relative importance of sewage treatment as compared with other municipal needs.

Unquestionably our various state departments of health ought to be clothed with very full powers of control over water pollution and also over both sewage and water purification. The more extensive these powers, the greater the need for good sanitary judgment and good common sense in their exercise. We venture to express the opinion that the confidence of the municipalities in state departments of health engaged in anti-water-pollution work would be greatly increased if the study of proposed sewage disposal plants were accompanied by a general review of the other sanitary needs of the municipalities in question. This, we are aware, would involve expense and difficulties which might prove insurmountable unless more money and men were at the disposal of State Health Departments. But even with present means we think that much more might be done in this line than has yet been attempted. It might very well be that a state department of health might sometimes advise a municipality to provide less elaborate methods of sewage treatment than were contemplated, or even to postpone sewage purification works until the purity of the water-supply or of the milk-supply, or perhaps a thorough reorganization and radical extension of the whole work of the local board of health, were made.

In conclusion, we wish to insist that, notwithstanding anything we have said, we think the general tenor of the proposed New York State amendments to the laws controlling sewage disposal and water pollution is right and that legislation of this general kind should be passed at an early date by New York or any other State still so backward as to be without it.

LETTERS TO THE EDITOR.

Progressive Tests on Aging Timber Needed.

Sir: In your issue of Aug. 18, p 184, under the heading of "Large-size Timber Tests," you give some very interesting information on the tests made by Prof. A. N. Talbot on full-size timber, such as bridge stringers. These tests are in the right direction and exceedingly valuable, but they do not go far enough. What is the strength of large-size timber, after being in use one, two, three, etc., years, until it is unfit for use? Until it is removed as unfit, it will be carrying the same load as when new, but with a diminishing strength probably after the first year. It is information on the margin of strength when old that is of vital importance.

Could a series of tests be made on old timber of known length of service, and up to the time of removal, it would add vastly to our knowledge, and assist the judgment of many an engineer often sorely in doubt.

Yours very truly,
G. B. Hazlehurst.

Catonsville, Md., Aug. 24, 1910.

[The United States Forest Service included tests of this nature in its program of 1903 and we understand is about to publish some results which may be of interest in this connection. When these results are available we shall be glad to make them public.—Ed.]

Laying Cast-Iron Pipe to True Curves by Deflections at the Joints.

Sir: In reply to inquiry of "H. McN.," in your issue of Sept. 1, 1910, would say that in locating the 24-in. additional supply main of this city, I have used a radius of 499.46 ft. (11° 30′ curve) as the minimum radius, this giving 1 7-32 ins. opening on base of wedge between hub and spigot at joints. The occasion for my using curves was to eliminate special castings in making a difficult location in a gorge and also in a tunnel to avoid a clay slide.

I am informed by Mr. Geo. T. Young, an engineer engaged on constructing the water-works of Carlisle, England, that only 1/16-in. at the base of the wedge was permitted as a maximum by James Mansergh & Sons, the engineers who designed the Carlisle works.

Respectfully,
James S. Haring, M. Am. Soc. C. E.

Ithaca, N. Y., Sept. 5, 1910.

Sir: In response to the letter of inquiry in your issue of Sept. 1, relative to laying cast-iron water pipe in curves, would say that I have just completed a line of 6-in. pipe a portion of which was on a curve of 240-ft. radius, and no difficulty was encountered in making joints and calking same. This corresponds to a deflection of 0.6-ft. per length of pipe. This curvature could have been exceeded, but just how much I am unable to say.

Yours truly,
C. H. Nicolet.

La Salle, Ill., Sept. 5, 1910.

Sir: Although "H. McN's" inquiry relates to bell and spigot pipe in 12-ft. lengths, it may interest him to know that universal cast-iron pipe in 6-ft. lengths with straight tapered, iron-to-iron machined flexible joints can be laid to any degree of curvature not exceeding three degrees deflection at each joint, regardless of the length of the pipe line. Two instances in actual experience of deflection with universal pipe are 6-in. pipe 80-ft. radius; 14-in. pipe 88-ft. radius.

Yours very truly,
Waddill Catchings,
Receiver for Central Foundry Co.
By J. A. Firriss.

Park Ave. and 135th St., New York City, Sept. 1, 1910.

Real Estate and Personalty in Machinery.

Sir: I note letter of A. B. on the above subject and your comments on same in Engineering News of September 1st. I recently had occasion to look into this matter and to consult with local assessors, from whom I learned that in Missouri the term "real estate" includes everything which is a part of the building or necessary for its occupation or use. This covers the heating plant, elevators, and the accompanying machinery and apparatus. There is some doubt as to the engines, dynamos, and power plant in a building [and boilers, if purely for power?—Ed.]. While these might be called "fixed machinery," they are not necessary for the operation of the building, as the service could be secured from outside sources. All other machinery, tools, etc., is considered as personal property. It simplifies the situation, of course, where the mortgage specifies exactly what it covers.

William H. Bryan,
Consulting Engineer.

St. Louis, Mo., Sept. 3, 1910.

[General definitions identical with the one above quoted or similar thereto are doubtless the ruling principle everywhere. Its weakness for the present purpose lies in not covering firstly outside structures, i. e., outside of and not connected with a building, which are not themselves buildings, and secondly, machines or structures connected with the use of the building and of substantial character but not necessarily serviceable to another tenant.

To illustrate the first case a pivoted yard crane is in point, especially when its pedestal rests on a masonry foundation; similarly a yard bridge-crane and its runway would be in point.

The second case is conveniently illustrated by a feedwater supply system in a shop-building located along a river or lake. This system comprises, we will say, an open or buried intake pipe with suction head in the water, a steam-pump in the boiler-room, and a wooden tank. The tank may be placed in the boiler-room, or on a low trestle outside, or on a high steel tower. None of the elements of the system was provided by the landlord, and none is concerned with the building or its water service, being used solely for feeding the boilers, which together with the engine were installed by the tenant. What parts of the system, if any, must be left behind when his lease expires and he moves to new quarters?—Ed.]

Notes and Queries.

In a footnote on p. 224 of our issue of Sept. 1, reference was made to an article "The Detailing of Skew Portals," by J. P. Davis. The date of this article should have read Feb. 11, 1909, instead of 1910.

AN 18-IN. ROCK DRILL, 9½ ft. long, has recently been tested at Bendigo, Victoria, Australia, in the construction of wharves. According to the "Engineering and Mining Journal," which quotes from the "Australian Mining Standard," the drill weighs about 3,000 lbs. and is capable of working in rock 40 to 50 ft. under water. The cylinder diameter is 8 ins. with a 12-in. stroke. The weight of the piston is 450 lbs.

A Novel Method of Jacking Caisson Piles for Underpinning.

The Astor Building, 16 Wall St., New York, an old eight-story office structure, adjoins the site of the new 39-story Bankers' Trust Building on the west. The latter is to be enclosed by a closed ring of concrete caissons, sunk about 65 ft. to rock, as the cellar stories extend come 35 ft. below ground water level. Before caissons could be sunk along the west edge, the shallow spread footings of the Astor Bldg., had to be underpinned by foundations carried to rock. For this purpose it was decided to sink caissons 36 ins. in diameter directly under the wall to rock, fill them with concrete and finally bring the wall to a firm bearing on them.

As load for forcing the caissons into the ground, the weight of the old Stevens Building at 18 Wall St. was utilized. The Breuchaud method of underpinning by jacking up against the building being underpinned has previously been used widely in work of this class. By the method here adopted the Astor Bldg. was left virtually untouched, except for cutting narrow recesses in the footing to give place for the caisson tubes, until the new foundations were completed, when the load of the wall was transferred to them by

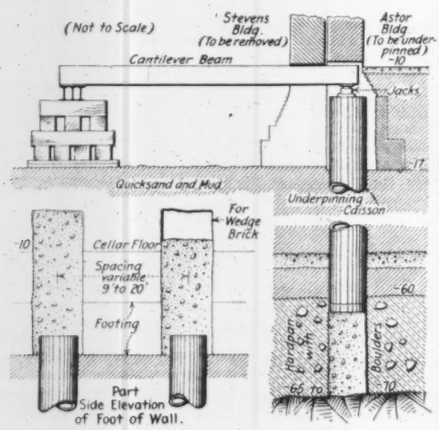

Fig. 1. Sketch of Method Used for Underpinning Astor Bldg. by Using Weight of Adjoining Building.

wedging. It was not necessary to occupy or enter the cellar of the Astor Bldg., during the underpinning, all work being done from the outside.

The sketch Fig. 1 illustrates the arrangement of the work clearly. The wall to be underpinned is represented at the right, and adjoining it at the left is the wall of the building which was to be removed. The latter provides an abutment for needle beams placed in slots through the wall, the jacks over the caissons bearing against the outer end of these beams.

The work required 11 of these caissons for a length of wall of 115 ft. The estimated load of the wall is 20 tons per lin. ft. The work proceeded without incident except that, as the demolition of the Stevens Bldg. was already going on, the weight over the beams decreased so much during the later stages that auxiliary loading by cast-iron weights had to be employed. The work was begun early in May, 1910, and was practically completed by the end of the month.

A special expedient was employed to sink the northerly caisson, because of its location. The rear wall of the old Stevens Bldg. was about 12 ft. forward (south) of the rear wall of the Astor Bldg. A cylinder was to be sunk under the side wall of the Astor Bldg. near its rear corner, and as the wall of the Stevens Bldg. was some distance away its weight could not be utilized directly by the method of Fig. 1 for sinking this caisson. The arrangement outlined by Fig. 2 was therefore devised, utilizing for reaction the weight of the Stevens Bldg. rear wall aided by two inclined struts whose upper ends had bearing against this wall and an opposing court wall. A 24-in. I-beam about 15 ft. long was placed close to and parallel with the Astor wall, with one end of the beam inserted through the rear wall of the Stevens Building. Crosswise under this I-beam there were placed three 24-in. horizontal I-beams with their short arms projecting into the recess in the Astor wall and their long arms taking bearing on the surface of the ground by blocking. The upper 24-in. I-beam acted as a fulcrum for the cantilever girder and the resistance to the upward reaction at the bottom flange of this fulcrum beam was provided by a pair of 12 × 12-in. inclined struts bearing against an angle block on the top flange of the fulcrum beam, the upper ends bearing in the court walls at a point about 20 ft. above the ground level.

The caissons for the Bankers' Trust Bldg. along this underpinned wall are now down to rock, and no settlement of the underpinned building has been found. The Foundation Co., of 115 Broadway, New York City, carried out the work.

Annual Convention of the American Public Health Association.

While improvements in sanitation and in matters of public health in this country have developed mainly within quite recent years, it is of interest to note that an association devoted to work of this kind was organized as long ago as 1872, and is now a flourishing and influential member of the family of public-welfare associations. It is partly technical in character and at its meeting last week it was decided to establish a sanitary engineering section. This society is the American Public Health Association, and its 38th annual meeting was held at Milwaukee, Wis., on Sept. 5 to 9. Mexico, Canada and Cuba are represented in the Association. The new President is a Canadian, and one of the new Vice-Presidents is a Mexican.

The sessions were held in different rooms of the Auditorium, a large building erected by the city a few years ago for the accommodation of conventions and other gatherings. The formal opening took place on the evening of Sept. 6, when the annual presidential address was delivered by Dr. Charles O. Probst (Columbus, O.). He emphasized the fact that ignorance is the common enemy of public health, and he advocated education along this line in the schools and colleges. He believes that a public sentiment is developing in favor of measures for promoting public health. Among other things he remarked upon the necessity of reducing the proportion of time given to work (more particularly by wage-earners), and of effecting a better division of the hours of work, rest and recreation.

There were six general meetings (lasting from three to four hours) and three sets of section meetings, so that each of the three sections (Laboratory, Vital Statistics and Municipal Health Officers) had three meetings. The list of papers was much too long to be handled satisfactorily; there were no less than 51 for the general meetings (exclusive of committee reports and routine business), and 37, 8 and 11 for the three sections, respectively. Some attempt was made to limit the time for the presentation of each paper, but with only partial success. There were many signs of weariness after the reading of a list of papers, each one good and interesting in itself but all together having a cumulative effect that was trying to the patience. Under these circumstances, there was little opportunity for discussion, and the program was disorganized considerably. The Laboratory Section, however, was notable for the live character of its proceedings. It has adopted the commendable rule of allowing a 10-minute limit for the presentation of each paper, and a 5-minute limit for each speaker in a discussion. As this rule is generally known, most of the papers were short, and both papers and discussions were to the point, so that interest did not flag.

One group of papers related to sanitary engineering (though many papers in other groups had somewhat similar relation), but this group came up at the close of the last session and received rather scant attention.

On the recommendation of the executive committee it was voted to establish a Sanitary Engineering Section and a Sociological Section. A resolution was adopted in favor of the Stevens bill, introduced in Congress for creating a department of public health as a branch of the government. The association decided to publish a monthly "Journal," beginning with January, 1911.

The election of officers resulted as follows: President, Dr. R. H. Simpson (Winnipeg, Canada); Vice-Presidents, Dr. Ferando Lopez (City of Mexico), Mr. John F. Anderson (Washington, D. C.), and Dr. G. A. Bading (Milwaukee, Wis.); Secretary, Dr. Wm. C. Woodward (Washington, D. C.). The officers of the three existing sections are as follows: (1) Laboratory; Chairman, Dr. John A. Amyot (Toronto, Canada); Secretary, B. R. Rickards (Columbus, O.); (2) Vital Statistics; Chairman, Dr. W. R. Batt (Harrisburg, Pa.); Secretary, Dr. F. L. Watson; (3) Municipal Health Officers; Chairman, Dr. A. J. Douglass (Winnipeg, Canada); Secretary, Dr. E. C. Levy (Richmond, Va.). The next meeting will be held at Havana, Cuba.

The subjects dealt with were so various and the papers so numerous that we can give only a brief summary of the matters of most direct interest to our readers.

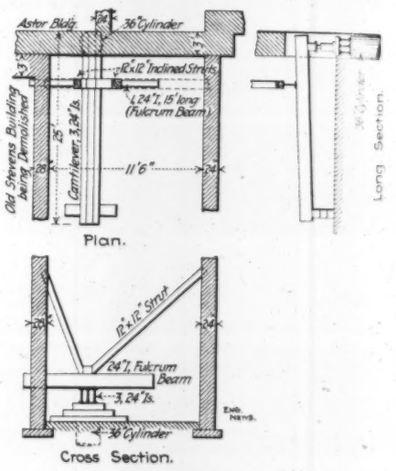

Fig. 2. Special Arrangement Used in Court of Stevens Bldg. to Obtain Reaction for Jacking Down Underpinning Caisson.

PUBLIC HEALTH ASSOCIATIONS. — The greater part of one meeting was devoted to the inter-relation of national organizations working in the interest of public health. Dr. Livingston Farrand (New York) outlined the work and purposes of the National Association for the Study and Prevention of Tuberculosis. The society aims at public education as to the dangers of infection, a public sentiment in favor of protection and prevention, and a public demand for legislation bearing upon these matters. It is recognized as useless to carry on such a work from one headquarters, and the society conducts a campaign for the establishment of local associations and arousing local authorities to an understanding of their responsibilities. In the discussion, Dr. Hurty (Indiana State Board of Health) deplored the difficulty of getting business men actively interested in this work.

Mr. L. Veiller (New York) spoke for the work of the National Housing Association. In many cases a hospital patient cured of some disease induced by unsanitary conditions goes back to live under the same conditions, with the probable result of further illness and perhaps death. Sanitary housing of the working classes of the poor is specially aimed at by this society.

Mr. O. R. Lovejoy (New York) reviewed the work of the National Child Labor Committee, established by Congress. He referred to the generally bad conditions regarding child labor, and the specially evil conditions in the south, where a large proportion of the mill workers are children who suffer under a combination of long

hours, enforced overwork and bad housing conditions. It may well be asked what is and what will be the degree of civilization where such conditions obtain and are persistently maintained. One of the most difficult problems is to convince business men of the economic and commercial side of these evils, as well as the sociological side. Dr. Herbert D. Pease (New York) spoke for the American Public Health Association and its work, referring particularly to the part taken by engineers and to the present movement for associating engineers even more closely with the work of the association. In all, eight papers were presented relating to various organizations in the general interests of public health.

ORGANIZATION FOR THE PROTECTION OF HEALTH.—Dr. Walter Wyman, Surgeon-General of the U. S. Public Health and Marine Hospital Service, outlined the methods taken by this government at Oriental ports and at the Washington laboratory to prevent the introduction of infectious diseases. The methods employed by the Canadian government were dealt with in two papers, by Dr. Frederick Montizambert, Director-General of Public Health, and Dr. C. A. Hodgetts, of the Canadian commission on conservation. A paper by Dr. Edwardo Liceaga, President of the Superior Board of Health (Mexico), was read by the Secretary; this dealt with the organization of the government sanitary service for the country itself and especially at the ports and frontier cities. Methods in use in Cuba were described briefly by Dr. F. Tarralbas.

Of a somewhat similar character were the papers on methods of handling state work. Dr. S. G. Dixon (Harrisburg, Pa.), outlined the organization of the several divisions of the State Health Department. He stated that one of the fundamental ideas of the work was that the people wanted to be healthy, and that the health department should seek to instruct them as to matters of sanitation. He remarked that the death rate in Pennsylvania has dropped from 16.5 per 1,000 in 1907 to 15.7 in 1908, and 15.3 in 1909. Mr. H. W. Clark (Boston) had a paper on "Research Work;" Dr. H. B. Hemenway (Evanston, Ill.,) dealt with "Executive Methods in Preventive Medicine," and Dr. C. A. Harper (Madison, Wis.,) discussed "The Relations between State and Municipal Boards of Health."

A paper by Prof. Wm. T. Sedgwick (Mass. Inst. of Technology) on the correlation of physicians, engineers and other experts, in public health work, may be mentioned as bearing upon the same general subject. A paper on "Social Economics and Public Health," by Mr. Emil Seidel (the "Socialist" Mayor of Milwaukee) dealt with modern industrial conditions, the concentration of wealth and the relations between employer and employee in the light of public welfare rather than in that of the inequitable distribution of wealth. He urged that it should not be in the power of one man or group of men to overwork and underpay others, compel them to work under bad conditions, and then (when they are used up) throw them out to be cared for by the government and the people in asylums and institutions. He laid particular stress upon this matter as relating to child labor. The paper was received with rounds of applause, indicating that the audience, while not composed of socialists, appreciated the mayor's point of view, especially in its application to the welfare of the child, as the future citizen. In fact, this appreciation of the urgent necessity for the protection of the child in its life and work was made evident at various times during the meeting.

THE UNIVERSITIES IN RELATION TO PUBLIC HEALTH WORK.—This paper was by Dr. H. W. Hill (Minneapolis) and some notes of this are given elsewhere. Very brief remarks in discussion were made by a representative of the University of Kansas, which university has the laboratory of the state board of health; by Dr. E. Bartow, who reviewed the various activities of the University of Illinois; by Dr. G. F. Ruediger, of Grand Forks, N. Dak., and by Dr. W. T. Snow, of the University of California. The last named, expressed the opinion that the legislature should not delegate any of the work of the state board of health to the university. The board should expend the money and plan the work, the university supplying the men (mainly for laboratory work).

WATER AND SEWAGE TREATMENT.—The purification or sterilization of water by treatment with hypochlorite of lime received its share of attention. A review of the whole subject was presented by Mr. Geo. A. Johnson, Assoc. M. Am. Soc. C. E., of Hering & Fuller, New York City. A paper by Mr. Charles P. Hoover (Assistant Chemist of the water purification works at Columbus, O.,) dealt with the electrolytic production of sodium hypochlorite. This substance has advantages over the calcium hypochlorite now used almost exclusively, but none of the electrolytic processes for the production of sodium hypochlorite have proved successful from an economical standpoint, so far as water purification is concerned. The paper described these different processes. A paper of practical interest, by H. A. Whittaker and J. A. Childs (Minneapolis), described a portable plant for treating a water-supply in an emergency, when it is discovered to be infected. In the discussion, it was pointed out that local authorities often delay in giving notice of the dangerous character of a water-supply for fear of creating a panic. But with such a plant available, the water can be under treatment in less time than notices to "boil the water," etc., could be given publicity. Then publicity could be given, with the added and reassuring fact that the water was already under treatment. The substance of this paper is printed elsewhere in this issue; also abstracts of paper by Dr. G. F. Ruediger (Grand Forks, N. D.,) are the self-purification of streams, and a paper by Dr. Arthur Lederer (Chicago) on the influence of dissolved oxygen in water upon the quality of the water.

A paper on "The Preservation of Sewage by Chloroform and Cold Storage," by Dr. Arthur Lederer and Harry B. Hommon (Sanitary District of Chicago) related to the preservation of sewage samples in their original condition until there is opportunity for their analysis. Ordinary fresh sewage will decompose readily on standing, and experiments have been made as to the changes which take place after the first six hours. But if no means of preservation are provided the analysis should be made before the samples are six hours' old, owing to the reduction in organic nitrogen and increase in free ammonia within that time. The great changes go on during the first 48 hours, after that the changes in nitrogen and free ammonia are comparatively slow.

Returns from 17 laboratories showed that when sewage samples can be analyzed on the day they are taken no preservative is used. Where a preservative is used this is generally chloroform, the amount ranging from 5 to 40 c. c. in 4 liters of sewage. From tests made of the 39th St. sewage pumping station, Chicago, it was found that 20 c. c. of chloroform per liter checks the decomposition (which still goes on rapidly), but that any further amount has no greater influence. The conclusion is that chloroform, even in large quantities does not preserve sewage at room temperature.

On the other hand, tests with cold storage showed that cold exercises a remarkable preservative influence, as far as the organic nitrogen and free ammonia are concerned. Chloroform, however, effectively prevents a decrease in nitrates and nitrites. The general conclusion, therefore, is that cold storage with the addition of 10 c. c. of chloroform per 4 liters of sewage, is preferable both to cold storage alone, and to warm storage with the addition of chloroform.

The purification of the water-supply of Richmond, Va., by sedimentation and coagulation, without filtration, was described in a paper by Mr. E. N. Ezekiel. Mr. E. B. Phelps (New York) presented a paper on the recent development and present status of the chemical disinfection of water and sewage.

SANITATION OF LABOR CAMPS.—A brief but interesting description of the sanitary supervision of labor camps upon the drainage area of the new Catskill water-supply system for New York City, was given by Dr. Herbert Pease, one of the sanitary experts for the Board of Water Supply. The necessity for such supervision appeared when contamination of the water-supply of Peekskill was traced to one of the camps mentioned. As the work will occupy about ten years and cost several million dollars it warranted the establishment of what is practically a health department specially to protect the drainage area of the new system, but also to protect the supply of the small towns on and near this area.

The camp sites are specially selected for efficiency in sanitary control. Each camp has a man-proof fence with only one entrance, so that the men and also their supplies of food, etc., are under control. Each camp has a general hospital and one for infectious diseases, and has a resident physician who is paid by the contractor, but must be approved by the Board. The buildings are one-story high, each holding not more than eight men. Infection by flies, food and contact is guarded against, and specially watch is kept for typhoid indications. All fecal and urinary discharges must be subject to treatment, but this is a difficult problem, owing to the character of the laborers. These are mainly foreigners, of careless and dirty habits and largely unintelligent. Methods that prove effective in U. S. Army camps are not satisfactory here, since the men are less intelligent and not under so good control. In addition there is the difficulty of making the contractors realize the vital necessity of intelligent and efficient supervision of the men and of the sanitary methods.

GARBAGE COLLECTION AND DISPOSAL.—A paper by Dr. P. M. Hall (Minneapolis) reviewed the objectionable and sometimes dangerously unsanitary conditions incident to the garbage can. These cans are rarely cleaned, and even when empty they are foul and form an attraction for flies and vermin. He did not think the system is to be abolished, but he suggested a means of mitigating the nuisance of the garbage can itself as well as that incident to the removal of garbage from the house to the can. The method is to let the excess water drain off in the kitchen sink and then wrap the garbage in paper and tie it in a bundle. These packages do not foul the can to any extent, they are conveniently handled at the house and by the garbage collector, the can ceases to be a breeding place for flies, and the contents of the can do not freeze solid in winter. The plan has been tried, and, although at first objected to by householders and derided as a "fad," it has proved successful.

The can should have a self-locking top, so that if it is upset, the contents will be retained and stray animals cannot get at them. In the discussion, a member spoke of the garbage cans as accentuating the rat problem at San Francisco, where rats are a means of spreading disease. Covered metal cans are now required, with a self-locking cover that fits outside the can. If made to fit inside, any deformation of the can prevents the cover from being closed properly.

A paper on "Modern Practice in Garbage Disposal" was presented by Mr. Rudolph Hering, M. Am. Soc. C. E. (New York), but was not read by him, as he stated it was a compilation of information already published in different places. In presenting it, however, he referred to the fact that local conditions must determine the proper method to be adopted in any case. Thus, while incineration has been found the most economical for Milwaukee, the reduction process has been found most suitable for Columbus, O. The utilization of garbage as fuel at electric light plants, etc., was mentioned, as well as the utilization of the heat for commercial purposes. In this connection Mr. Hering estimated that the steam now going to waste at the new incinerating plant at Milwaukee (Eng. News, July 21, 1910), represents a loss equivalent to $3,000 per month.

SANITATION OF FOOD.—An interesting feature of one of the meetings was the adaptation of the "moving picture" to purposes of public health. Two films were exhibited by Mr. Wat-

rous, of the American Civic Association, and these had been prepared specially for public education. One of these showed the life and customs of the fly, with its frequent feeding on decayed matter and its opportunities of carrying filth and infection to food. It was stated that in one city the police censors refused to allow the pictures to be shown, as being of too disgusting a character. The Civic Association then undertook to explain very fully to the authorities the real purpose of the exhibition as a means of public education in an important matter of public health, and especially in relation to infant mortality. As a result, the pictures have now been approved for exhibition in that city.

The second series of pictures showed first the common unsanitary methods of handling and milking cows, and of handling the milk from the time it leaves the cow barn till it reaches the ultimate consumer. The battered milk can in the door of a shop, and the ladling of milk from this into the customer's pail by a dipper that lay in the open shop window were all shown. Following this were views of a sanitary cow barn and milking methods, with a bottling machine at the dairy, so that the milk is not touched by hand and is sealed at once in the bottles. This series of pictures was arranged as a "story," not for theatrical effect, but in order to make the pictures appeal more directly to an ordinary audience. The old farmer refuses to listen to arguments as to his unsanitary methods until his little grandson comes near death through the use of the milk. The doctor convinces the old man of the cause of the child's illness, and in gratitude for the child's restoration to health the old man adopts modern sanitary methods. The pictures were received with tremendous applause, and it was the general impression that their exhibition to the public would have a direct educational effect.

Papers relating to food supplies included the results of bacterial analyses of shell and shucked oysters, and these results were by no means pleasing. A preliminary report was read from Mr. G. C. Whipple (New York), chairman of the committee on standard methods of shell fish examination. Bakery and kitchen conditions were dealt with by Mr. C. B. Ball, M. Am. Soc. C. E. (Chicago), and there were other papers on milk supply and its protection.

VITAL STATISTICS.—The association has a separate section devoted to this subject, but this did not include all the papers relating to this subject. One group of papers related to the registration of births, and the importance of this registration in the determination of infant mortality. Many other papers (including some of those on the sanitation of foods) related especially to the prevention of many causes of sickness and death among children. A paper by Dr. Marshall L. Price (Maryland State Board of Health) outlined especially the work of an association devoted to the study and prevention of infant mortality. Other papers dealt with the registration of marriages, and the subject of registration in general, including the obstacles encumbered in the application of the laws relating to this matter.

MISCELLANEOUS.—One group of papers related to the testing and bacterial standardization of disinfectants; this included a verbal report of progress of the committee on standard methods of testing, by Dr. J. J. Kinyon (Washington, D. C.) The disinfection of books by the carbo-gasoline method was described by Mr. W. L. Beebe (St. Paul). In the discussion, Mr. B. R. Rickards (Columbus, O.) spoke of trouble at a public library. Formaldehyde, as used in disinfecting rooms, was found to be ineffectual, as it did not kill the organisms. Dry (superheated) steam was effectual, but it shrivels up the leather bindings, and the heat was so great that if the paper came in contact with any metal it was scorched.

Anti-typhoid vaccination in the army was dealt with by Major F. F. Russell, of the Medical Corps, U. S. A. He showed the satisfactory results obtained in this country and in India, South Africa and German East Africa. In one trial, of 12,000 men, the typhoid cases were 3% among those vaccinated and 28% among those not vaccinated. The reaction was not severe, as is sometimes supposed; in fact 95% of the men treated suffered little inconvenience. About 14% of the men in the U. S. army have been treated. A paper by Dr. L. L. Lumsden (Chicago) discussed the need of uniformity of methods in the investigation of typhoid fever in municipalities.

Abstracts of Papers Read at the Convention of the American Public Health Association.

A large number of useful and interesting papers were read at this convention, and we present herewith abstracts of a few of these. A report of the convention proceedings will be found elsewhere in this issue.

A Portable Hypochlorite Water Treatment Plant for Emergency Use.

By H. A. WHITTAKER and J. A. CHILDS.*

The results obtained with the hypochlorite treatment of water point to the use of this disinfectant as a very satisfactory method of sterilizing water-supplies. In Minnesota, calcium hypochlorite has been used in several instances with success. The small amount of apparatus required, and the low cost involved in purifying large amounts of water, make it possible to install such plants quickly, thus rendering the treatment readily applicable to infected water supplies. Where the evidence points to such a supply as the cause of an epidemic, sterilization is the best means of preventing further infection. In such cases, immediate sterilization is necessary, as it is impossible to prevent a certain proportion of the population from drinking the water, even with the most efficient publicity on the part of the local health department.

Whenever it has been necessary to install an emergency hypochlorite plant in the small municipalities of Minnesota, the time required has usually consumed the greater part of a week, and in some cases the time has been larger. This delay is caused usually by lack of material with which to properly construct the apparatus necessary to administer the chemical. This gives opportunity for further exposure to infection.

After actual experience with such delays, it appeared that a small emergency plant could be constructed and kept in readiness by the State Board of Health. Such a plant could be transported by express to any municipality within 24 hours, and in most cases it could be installed and in operation within 48 hours. This plan was presented to the Board at a recent meeting. The construction and maintenance of such a plant was authorized, and designs are being prepared.

This plant will consist of a mixing tank, storage tanks, and administering device. The mixing tank will be about 30 ins. diameter and 30 ins. deep. In it is a conical chamber, having its small end about 1 in. from the bottom. A propeller revolving in this chamber causes the solution in the tank to circulate through the chamber (in either direction as desired), thus securing rapidly a uniform solution. This is drawn off into two 50-gal. storage barrels, which are used alternately. From the barrels the solution is fed into the administering box, in which a constant level is maintained, and from which the solution is fed to the water-supply at the desired rate.

It is estimated that this plant will treat easily a water-supply at the rate or 1,000,000 gals. per day, which is about the maximum consumption of most of the smaller municipalities of Minnesota.

*Minneapolis, Minn.

The Self-Purification of Streams as Affected by Changes of Season.

By GUSTAV F. RUEDIGER, M. D.†

While making routine bacteriological examinations of the water-supply of Grand Forks, N. Dak., I was impressed by the fact that both the raw and filtered water contains many more colon bacilli during the winter months (when the river is covered with a thick layer of ice), than during the summer months, when the river is open. The supply is taken from Red Lake River (in Minnesota), which is polluted with the raw sewage of Crookston, Minn., a city of about 7,000 population. The distance along the river is 80 or 90 miles, and it takes about 48 hours for the water to flow from Crookston to Grand Forks.

As the amount of excretal waste in the sewage, and hence the number of colon bacilli in it, at the point where the sewage enters the river, are presumably as large in the summer as in the winter, it has seemed that there must be a much more rapid destruction of these organisms in the river during the summer months.

We know from the exhaustive studies of Russell, Jordan and Zeit, and others, that typhoid bacilli and colon bacilli do not survive many days in the wa[ter of a] heavily polluted river. In all of these studies [the river,] not much attention was paid to the seasonal [variation] in the self-purification of the streams studied.

The amount of sewage entering a river from [a small] city varies greatly during a 24-hour period. [Samples] collected at intervals of six hours, at a point in [the mid]dle of the river, about ¾-mile below the outl[et of the] sewer at Crookston, showed respectively 28, 27, [and] 8 B. coli per c. c. Therefore, it is essential [to collect] at least three or four samples be collected and [examined] during a 24-hour period.

The accompanying table shows that the water [contains] from four to five times as many B. coli per c. c. [during] the winter as it does during the early part of the summer. The amount of pollution at Crookston is approximately the same the year around and hence this difference must be due to a more rapid destruction of these organisms during the summer months. It must be admitted that we have no means of determining how many B. coli get into the river from fields and barnyards. It is certain, however, that more of these organisms would get into the water from the latter sources during the summer than during the winter. Therefore this factor does not weaken the conclusions to be drawn from the analyses.

The volume of water in the river varies greatly at different times of the year, but the U. S. Geological Survey takes daily readings to estimate the average daily flow. I am indebted to Prof. E. F. Chandler, of the University of North Dakota, for the figures in the table. If from these figures we calculate the number of B. coli that would be found if there were no variation in the dilution, we find that these agree very closely with those found in the analyses. These calculations are made on the basis of a flow of 750 cu. ft. per sec., which is about the average for the year.

Our experiments, made with dialysers suspended in the river, show clearly that typhoid bacilli will live five or six times as long in polluted river water when the river is covered with a thick layer of ice as they will in that same river during the summer months, when the river is open.

Further experiments were carried out to determine if possible just what forces in nature are responsible for the self-purification of this river during the summer months, but are wanting, or much less effective, when the river is covered with ice. The experiments thus far indicate that the growth of microscopic plants and saprophytic bacteria is the most important factor, but the effects of the sun's rays also are of great importance.

CONCLUSIONS.—Colon bacilli and typhoid bacilli disappear much more rapidly from polluted river water during the summer months than during the winter months when the river is covered with ice and snow.

The destruction of these organisms in the river water is in large measure due to the growth of microscopic plants and other organisms which apparently give off dialysable substances which are harmful to B. coli and B. typhosus. That such substances are given off by the saprophytic bacteria was clearly shown by Frost several years ago, and my experiments simply confirm his by attacking the problem in a slightly different way. These effects are lost in the winter as no growth takes place at 0° C. The direct rays of the sun also are an important factor, and their effects are entirely lost when the river is covered with a thick layer of ice and snow.

VARIATION OF NUMBER OF B. COLI PER C. C. IN RED LAKE RIVER WATER. SAMPLES COLLECTED ABOVE GRAND FORKS, NO. DAK.; POLLUTION AT CROOKSTON, MINN.

Date.	B. coli, c. c.*	Volume of water in river: cu. ft. per sec.	Calculated B. coli per c. c. if volume of water always = 750 cu. ft.
River Not Covered With Ice.			
June 18, 1909....	*2½	1,120	3.0
July 12, 1909....	3½	782	5.5
Sept. 11, 1909....	6¼	1,000	4.8
June 4, 1910....	2	1,180	3.3
June 28, 1910....	5½	750	5.5
Aug. 15, 1910....	6	300	2.0
River Covered with Ice (average thickness 30 ins.)			
Jan. 18, 1910....	15½	770	15.5
Mar. 1, 1910....	17½	610	14.0

*These figures represent the average of four analyses of samples collected at intervals of six hours.

The Relation of the University to Public Health Work.

By Dr. H. W. HILL.*

The state boards of health are few in number but immensely influential. They have common interests, and the tendency of their inter-relations has been to unify methods and to secure cooperation. Universities also are bodies of high intelligence and high purpose. It is the university which usually seeks alliance with the board of health, and the latter should be prepared to make equitable propositions. The alliances hereafter made have commonly taken the form of securing for the board's laboratory a location with facilities [drawn] from the university medical school. The saving in rent and equipment appeal to the health board. The [univer]

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versity counts upon the value of having the board's laboratory upon its grounds, the educational value to the students, and the supply of abundant material for teaching purposes.

The cooperative idea is also a strong one. The state board hopes to secure a certain amount of help, advice, support, or even prestige from its university connections. The university hopes to be able to show its labors in connection with the State board of health as an example of the practical character of its work, outside of and in addition to the teaching of students. Mutually, both bodies hope that the alliance will prove of value in securing legislative support and impressing the alumni (especially the medical alumni) with the advances which have been achieved.

Beyond laboratory alliances, attempts have been made to secure cooperation in engineering and in epidemiological fields. To the overworked and shorthanded state board, visions appear of troops of well-trained, energetic young students, medical and engineering, flocking out, under the guidance of their professors, to investigate at the emergency call of the state boards, epidemics of typhoid, or problems in sewage disposal or water-supply. To the university man, weary of book teaching and anxious to demonstrate to his students what an epidemic is and how to handle it in practice or to solve actual water-supply problems on the ground rather than paper problems in the classroom, the same vision appears, although with a very different aspect and meaning.

Each must perform its proper duties in its own sphere before reaching out to aid the other. Always there must be the line drawn between what must be done, to fulfill each its own functions, and what may be done by cooperation to aid in general progress. The State board is an arm of the government; it exercises some of the police power of the state; it has certain very definite responsibilities and obligations which it can share with no one ethically, legally or practically. The university is a teaching body under the control of the state. Its responsibilities cease with the proper education of its students, however, broadly "proper education" may and should be interpreted.

The Relation of Dissolved Oxygen in Water to the Quality of the Water.

By DR. ARTHUR LEDERER.*

The determination of dissolved oxygen is an extremely valuable aid in the differentiation of the quality of a water or a sewage effluent, but must be used with caution in formulating a definite opinion. A good water should be well aerated and comparatively high in dissolved oxygen, but the actual content is of less importance than the stability of the oxygen. Two samples, both apparently clear and inviting, may show the same dissolved oxygen content (say 9 or 10 parts per million). One may be Lake Michigan water, non-putrescible, with a bacterial count of 200 to 300 per c. c.; the other may be the effluent of a sprinkling filter, with 20,000 to 80,000 bacteria per c c., and the great majority of them being acid formers. But when kept under perfect anaerobic conditions for 24 hours in a glass bottle at 22° C., one will show, say, an elongation of about 10% of the dissolved oxygen by the oxidizable matter, while the other will show an absorption of 80%. The dissolved oxygen of the latter will be almost completely exhausted in two or three days. In other words, the latter water would work serious harm in a fresh watercourse. The rate of absorption, therefore, is a valuable indication of the quality of the water.

Tests of samples of lake water and sewage have shown that cold storage has a retarding effect upon the absorption, but that the effect is very much less with sewage than with water. The following conclusions are presented:

(1) The rate of reduction of dissolved oxygen in waters which are stored in tightly closed bottles and exposed to a constant temperature for a definite length of time, constitutes a fair index of considerable pollution.

(2) To unpreserved samples of polluted waters, the reagents for the determination of the dissolved oxygen must be added on the spot to avoid a reduction. In a pure water, such as Lake Michigan water, the samples if stored at a low temperature can be kept for a few hours without material reduction.

(3) The addition of 1 c. c. of 40% formaldehyde solution to a sample of water, even if badly polluted, will preserve the amount of dissolved oxygen present for at least two days in storage at 22° C. and for at least four days at 10° C.

(4) If kept in a dark place, a sample of water taken under the necessary precautions to avoid aeration, can be preserved with formaldehyde for a reasonable length of time and shipped to the laboratory without danger. Thus no field apparatus is required, except the device for taking the sample and a bottle of formaldehyde. In calculating the final result a correction must be made for the amount of sample displaced by the addition of the preservative.

ACCIDENTS TO MOUNTAIN CLIMBERS in the Alps, were unusually numerous in the year 1909, according to a report by U. S. Consul Francis B. Keene, of Geneva, Switzerland. In the climbing season of that year more than 150 climbers were killed outright or died from the effects of injuries.

*Chemist and Bacteriologist of the Sanitary District of Chicago, Chicago, Ill.

A School of Municipal Accounting and Reporting, Under the New York Bureau of Municipal Research.*

By HERMAN A. METZ.†

During my present trip on this side of the ocean, I have been impressed by the fact that, in Germany especially, the uniformity of accounting methods among the larger cities give a much better basis for comparison as to cost of administration, maintenance, etc., than we have at home. As even under our various systems of administration of municipal affairs, all our cities are dependent upon their ability to float their bonds, and apparently in ever increasing amounts, it would seem only natural that bond buyers should have a means of ascertaining what financial and accounting methods are in force in the respective cities and be able to make comparison as to credit ability, based on something more than a general legal provision as to borrowing capacity.

I am writing you therefore to ask your personal and official cooperation in some educational work in which we both have an interest, and to apprise you of my purpose to provide a fund of $10,000 a year for three years to make available to American cities the best principles and practice worked out in municipal accounting and reporting.

The fund is to be administered by the directors of the New York Bureau of Municipal Research. But having in mind its national application through the cooperation of various comptrollers, I am keeping it as a separate fund. While it is obvious that the $10,000 will not reorganize the accounts of all American cities, it should, however, be sufficient to make available to all cities the results of the experience which is being acquired in each. For example, New York City has spent for the last several years past, thousands of dollars in working out principles and in demonstrating the practical application of accounting methods to municipal business. A good deal of progress was made during my administration as comptroller, and I am glad to see that my successor in office is continuing the work which began under me. Every city in America should have the benefit of the work which is now being effectively carried on, and New York should have the benefit of the experience of your city and of other cities.

City comptrollers, as you know, continually receive letters of inquiry, requesting just the kind of information which I have in mind to acquire and circulate through such an agency. Only to-day I received, through my New York office, an inquiry from the deputy comptroller of Milwaukee asking for information as to the changes made in New York methods and as to what legislation, if any, had been necessary to bring about the improvements. To-day it is nobody's business, and nobody has either the funds or organization, to give the kind of answer that ought to be given when one comptroller writes to another comptroller for information.

I might cite a personal experience which illustrates the difficulty which I have in mind: An inquiry recently made by the Bureau of Municipal Research for Comptroller Prendergast showed that my own records of what the bookkeepers were doing in my personal business establishment, and the records of what the bookkeepers in the comptroller's office were doing, were widely divergent; that bookkeepers were doing five times as much work for me every day as an employer as they did for me as comptroller and did not complain of being over-worked at that. As every business man knows, the quantity of work performed by his employees is largely determined by the methods and conditions under which their work is done. The point is, that the only way to correct such discrepancies is to provide cities with business-like methods of accounting and reporting that will keep the facts before the officers and the people who elect them, and do it by up-to-date and easily understood balance sheets and statements.

*A letter to Mr. Alonzo Tweedale, President of American Society of Comptrollers and Auditor of the District of Columbia.

†Of H. A. Metz & Co., 122 Hudson St., New York City, recently Comptroller of New York City.

A Train Resistance Test Covering a Trip of 4,530 Miles.

Train resistance tests are confined as a rule to short runs or to a single division of a railway, but the Atchison, Topeka & Santa Fe Ry. has made the unique experiment of running a dynamometer car attached to a regular train for the entire trip over the main line from Chicago to Los Angeles and return. The work and observations were under the direction of Mr. H. B. MacFarland, Engineer of Tests, to whom we are indebted for the information here given. The results of the tests are not yet ready for publication.

The object of this test was to determine train resistance on the various divisions of the main line of the company's system. The present passenger traffic is so great as to require a considerable number of trains being double-headed on much of the territory of the system. The success already attained with Mallet duplex engines for passenger service in California is such as to warrant thorough investigation regarding the distribution of the present motive-power equipment and the consideration of the introduction of engines of sufficient power to handle trains on schedule time without the necessity of double-heading.

The test train started from Chicago on Saturday, Aug. 20, at 10 p. m., with 15 cars (including the Westinghouse dynamometer car No. 5), having a total train tonnage of 849 tons. This train was made up as regular passengtr train No. 1, running to Los Angeles, and contained sufficient deadhead equipment to maintain the tonnage very close to 825 tons over the entire system. The train arrived at Los Angeles on Wednesday, Aug. 24, and left Los Angeles on the return trip as regular train No. 10 on Friday, Aug. 26. The train tonnage for the return trip was maintained at approximately 825 tons (15 cars) as before. At points where it was necessary to divert cars to portions other than main lines, dead-head or other equipment was attached to maintain the approximate tonnage.

There were 26 engine changes during the entire trip. On maximum mountain grades of over 3%, pusher engines were used in order to maintain a minimum speed of 20 m. p. h.

During the test, the dynamometer car was in constant operation, recording drawbar pull and speed. Consequently train resistance on different conditions of track and grades at different operating speeds was easily determined. Records were also made of the time of passing stations and mile-posts throughout the entire trip. The number of brake applications and the drawbar pull necessary to start train at different stations and under widely different conditions was also obtained.

The total distance from Chicago to Los Angeles and return is 4,530 miles. In order to get specific information as to train resistance and influence of curvature, distance signals were recorded on the chart for every other telegraph post, of which there are some 84,000 between Chicago and Los Angeles.

The results of the test will be worked up and presented graphically on a scale of two miles to the inch. The charts will show (1) a profile of grade, (2) total drawbar pull, (3) speed, (4) total resistance of train per ton, (5) resistance per ton of train neglecting grade resistance, and (6) total energy necessary to move the train through each mile.

THE EARLY HISTORY OF THE MADEIRA & MARMORE Railway (See Eng. News, Oct. 17, 1907, p. 426, and Oct. 24, 1907, p. 449), as many of our readers will remember, was notorious for the loss of life, due in large part to the natural unsanitary conditions of that part of the world. Some of these conditions still prevail, but are to be made the subject of attack along modern lines of tropical sanitation. According to U. S. Vice-Consul J. J. Slechta, Rio de Janeiro, this compaign will be led by Dr. Oswald Cruz, who, Mr. Slechta states, "did so much to transform Rio de Janeiro from one of the most unhealthful to one of the most healthful cities." We quote from Mr. Slechta's report further, as follows:

The first work to be undertaken will be in the region now occupied by the American contractors who are building the railroad around the falls of the Madeira and Marmore rivers, 500 miles to the south of the export rubber market of Manaos. American medical men have been employed by the contractors and builders of this railroad to relieve the situation, so far as possible, of the dreaded yellow fever, beriberi, and other diseases which afflict workmen in that region, and they have accomplished much, but that the situation is not yet all it should be is evidenced by the contract which the company has made with Doctor Cruz, who is to direct the work of sanitation along the right-of-way of the railroad, and utilize for that purpose some of the experience he has had in wiping out yellow fever in Rio de Janeiro.

Mr. Slechta also states that after completing the work proposed for him in the Madeira-Marmore region, Dr. Cruz will give his services to a company engaged in contract work at Para, at the mouth of the Amazon. The particular object of the campaign at Para will be the destruction of yellow fever.

A Three-Hinged Concrete Arch Covering Over a Canal in Paris, France.

As a part of the extensive canal system that covered the entire country in the ante-railway days, the city of Paris, France, has a great number of small canals branching up from the Seine to the various quarters of the city and terminating generally in wide basins in which freight unloading and loading can be carried on. Although the main systems are not as much used as in the past these minor branches still carry considerable traffic and are very valuable to the trade of Paris. The open canals are, however, not sightly nor sanitary and the area they occupy between the houses is much more useful as a street, so that from time to time covers are being put over the canal, leaving a channel beneath for the boats and a street above for vehicles. Naturally, the water surface of the canals is not very far below the level of the adjoining streets, so that the problem of covering the canals level with the street, in order that sufficient clearance be provided for the boats, is quite a difficult one, particularly when the channel is widened for the loading basins. In a recent issue of "L. Genie Civil," M. Mesnager, of the corps of Ponts et Chausées, describes in some detail the use of a three-hinged concrete arch for such a covering.

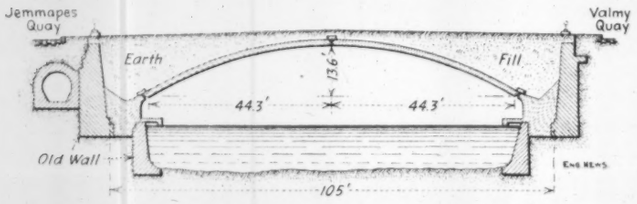

FIG. 1. SECTION THROUGH THE TEMPLE BASIN OF THE ST. MARTIN CANAL, PARIS, SHOWING THE CONCRETE ARCH COVERING.

We have abstracted the following short description from that article.

The canal to be covered is the Temple basin (Bassin du Temple) of the St. Martin canal, some 800 ft. in length, with a clear waterway of 90 ft. and opening between tops of retaining walls about 110 ft. The water surface is about 22 ft. below the level of the adjacent sidewalks, so that to get the required 15 ft. clearance in the middle as well as a fair clearance for the tow paths made necessary a flat arch or a truss. On account of the long span the former was adopted and a specially designed reinforced concrete three-hinged arch built over the entire length of the basin.

Fig. 1 shows the general section through the covered canal. Originally the section consisted of 90 ft. of water of 9.2 ft. depth, held by low retaining walls outside of which were the narrow tow paths and then high retaining walls holding back the adjacent streets. The new arch is footed into the ground occupied by the tow paths and new paths are made by cantilevers from the abutments. These abutments are built well down into the earth and up to the level of the hinges, from which springs the thin arch. Above the arch there is an earth fill to the street level and upon its top is built a wide parked boulevard.

Details of the arch are shown in the accompanying figures. Its main points of novelty are the design of the hinges and the fact that the arch barrel was constructed for the whole 800 ft. of the basin with no expansion joints. It is a three-hinged arch 88.6 ft. between springing hinges and with 13.6 ft. rise. The section is 12 ins. thick at the thickest points, near the haunches, 11½ ins. at the spring and 10½ ins. at the crown. Every 42.7 ft. there is provided a rib or counterfort 13½ ins. wide extending up a variable distance from the main arch rib and tied thereto by reinforcement. Reinforcement in the main rib consists of a network of rods at the upper and lower planes, ⅝-in. rods spaced 8 ins. c. to c., running transverse to the axis and ⅜-in. rods, 8 ins. c. to c., running parallel to the axis. At the counterforts the upper line of transverse rods are carried to the top of the counterfort as shown in Fig. 2. Stirrups, 1⅛ × 1-16-in. in section, tie the upper and lower transverse bars together, at distances of 3.3 ft. apart.

The hinges are shown in Fig. 3. They comprise a series of groups of closely packed round rods, embedded back into the arch rib and into the abutment and covered at the hinge proper with a thin layer of concrete for protection against the weather. At the springing hinge, the rods are of 15-16-in. diameter, spaced in groups of four, 6 ins. c. to c. The rods are disposed through the depth of the rib starting parallel to the extrados and intrados about 3.4 ft. from the hinge, but they all bend to pass the middle of the hinge and then spread again in the abutment. At the crown the same arrangement prevails, but ⅝-in. rounds are used and the spacing of the groups is 8 ins. c. to c. At the hinge center the rods are protected with about ¾-in. of concrete above and below, which concrete is continuous between the groups of rods. The reinforcement in the arch rib itself stops just short of the hinge opening. The top of the arch was covered with two layers of tar before the earth was placed and this was continued, as shown, over the hinge openings.

In the construction of the arch an open waterway had to be kept in the canal, so a special centering was designed. This consist[ed] of ordinary pile and timber falsework for [the] shore segments extending some 30 ft. from [each] side and carrying on the top of the inside pil[es] steel truss over the intervening waterway. [These] frames were spaced 8 ft. c. to c. a[nd were] braced together in groups of five, spa[nning] 40 ft. parallel to the axis of the canal. [Concrete] was then laid continuously over this 40 [ft.] section, the falsework taken down from [the] preceding 40-ft. section and carried ahead, [the] process being continued till the work was [finished]. At the end of each section the longitudin[al] rods were left protruding so as to form an [effective] bond, making the whole arch continuous.

The arch has been in service now ab[out] two years and has passed through the heavy [floods] of last winter. It has stood up very [well] in service and no deterioration is marked, [except] that a number of transverse cracks ha[ve] appeared at or near the lines where the centering was moved ahead. This would indicate that expansion joints along the barrel of the arch every 40 or 50 ft. might have been provided. As it is these cracks have formed themselves, and it is probable serve the purpose as well as though they had been so designed.

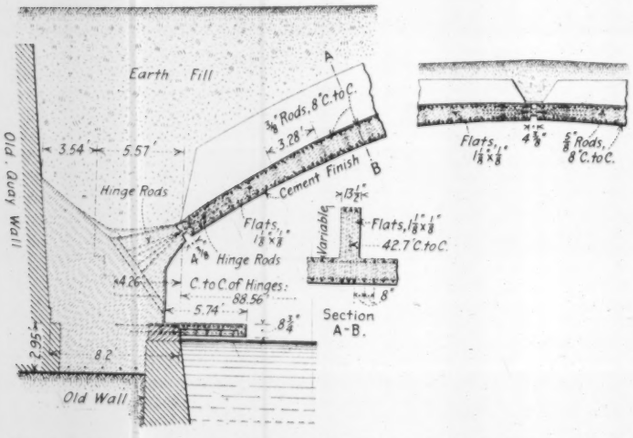

FIG. 2. DETAILS OF THE ARCH RIB OF THE ST. MARTIN CANAL COVERING.

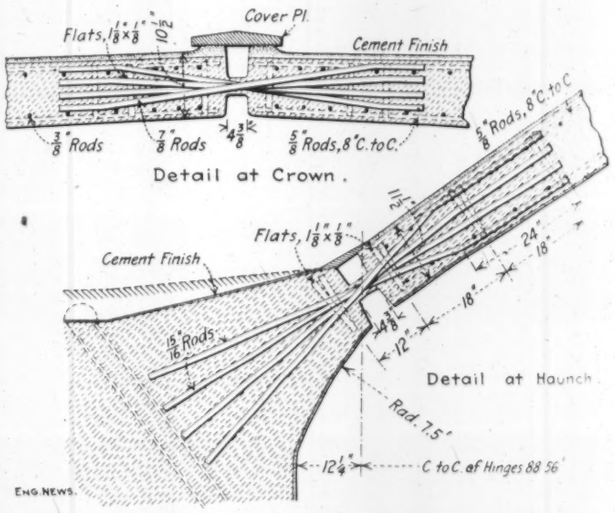

FIG. 3. HINGE DETAILS OF THE ST. MARTIN CANAL ARCH.

THE 50TH ANNIVERSARY of the introduction of street railways in Great Britain occurred on Aug. 30. On that date in 1860, the late George Francis Train, of New York, well known in his later years for his eccentricities, opened a horse car line 1½ miles long in Birkenhead, opposite Liverpool. Train had first attempted to build a road in Liverpool itself but was unsuccessful there. In Birkenhead, however, he secured the cooperation of John Laird, the ship builder, then Chairman of the Commissioners of Birkenhead and afterwards widely known as builder of the Confederate cruiser "Alabama." Train styled this initial road "The Cis-Atlantic Railway." It was of standard gage and was laid with the "step" rail commonly used for horse car lines. Following his success at Birkenhead, Train promoted horse-car lines in London and three such lines were constructed the first being opened on March 23, 1861. After a year of operation, however, the obstruction offered by the rails to other traffic and the opposition of the omnibus interests compelled the abandonment of these lines. It was not till 1869 that the first Acts of Parliament were passed authorizing street railway construction in London, and even to-day surface street railways in London are limited in extent.

As English cities were slow to adopt horse-car lines, so mechanical traction on street railways was postponed till long after it had proved a success in the United States. One reason for this was the long maintained opposition to overhead trolley wires. Another reason was the unwillingness of the cities to grant franchises to promoters for the use of the streets. The first trolley road in the United Kingdom was opened on Nov. 10, 1891, a line 3½ miles long at Leeds owned by the municipality. A pioneer electric conduit road at Blackpool, however, was opened in 1884 and continued in operation until it was converted to the overhead trolley system in the '90's. The above statements are given on the authority of a London "Times" correspondent.

Exterior Treatment of Concrete Surfaces: Committee Report to the National Association of Cement Users.

At the last annual meeting of the National Association of Cement Users in Chicago in January, 1910, the Committee on Exterior Treatment of Concrete Surfaces, of which Mr. L. C. Wason, of Boston, Mass., is chairman, brought in an extensive report. At that time the report was not quite complete and could not be published, but the new matter has since been added, and we reproduce below the completed report, somewhat condensed and abstracted. It is the first complete discussion of the subject and contains much valuable information.

Effect of Material and Workmanship on Surface.

This heading pre-supposes that the surface will be treated in some way so as to remove the surface coat, otherwise the ingredients of the mortar or concrete would make little difference.

CEMENT.—The color of the surface is largely that of the cement which is used. Although there is some difference in the shade of gray of standard Portland cements, the difference is so slight that with very few exceptions no thought need be given to the color of cement. There are also some white cements on the market which give a very pleasing treatment to the finished surface. Consideration should be given to some extent to seasoning, as a well seasoned cement is less likely to cause craze cracking or shrinkage cracks than one which is fresh. The subject of fineness of grinding is of less importance but is worthy of some consideration.

SAND.—If the surface is tooled or scrubbed, particles of sand will be exposed to view and their color will have an important influence upon that of the surface. Their size will also have an influence upon the texture. A sand with large round grains such as is found on the sea coast in places, the grains being practically of one size, cannot be used in as rich a mixture as sand of variable size and angular grains, because the round grains will rub from the surface with considerable readiness if the mixture is 1:2 or leaner, and as the grains in the first named sand are large they have more influence upon the color than sand of variable sizes. A light gray or white quartz sand will lighten up the color of the mortar very materially so that it would appear that some pigment had been used with the cement. Stone dust makes an excellent sand and when of a grayish color can scarcely be distinguished from that of the cement, thus giving a uniform appearance. Quite a variety of colors and textures can be obtained by care in selecting the sand, either natural or stone dust, of variable sized grains, ranging from that which will pass a 30-mesh sieve to that which would just barely be rejected upon a ¼-in. sieve.

STONE.—The stone, still more than the sand, can be used to vary the appearance of the finished surface on account of its larger size and ease with which it can be cleaned of cement when the latter is still green. It is possible to get a very wide range of colors in stone and one color can be used or two or more can be mixed together and give very pleasing effects, the size ranging from rejection of the ¼-in. sieve to that which would just pass a 2-in. ring. Contrasting the angularity of broken stone with the round and smoother surfaces of gravel, gives effects which are still more varied than with quarry stone, and are just as durable so far as strength and waterproofness are concerned.

FOREIGN MATTER.—It is also possible to get some pleasing effects by the introduction of foreign matter such as broken brick, glass, fragments of metal like copper, brass and even nails are sometimes used, but the rust and stain from iron nails is unsightly. Sometimes ores, such as the green ore of copper, have been used for producing certain effects. Oil, glue, lime, have also been introduced at times for certain purposes. In one instance the following mixture was used: To every barrel of cement was added 4 lbs. of salt and 20 lbs. of quicklime slacked for one week, passed through a fine screen, 4 lbs. of lampblack and 1 lb. of linseed oil. In preparing this the lime was first slacked and while yet hot the salt in solution together with the lampblack and oil, were added and all stirred thoroughly together, the mixture then being passed through a fine screen into vats and allowed to stand for one week or longer before using. The proportion of the cement aggregates was one to six, the stone being a mixture of dark blue trap and white marble.

WATER.—Water has its influence on the appearance of the surface in several ways. The amount of water has an influence on the density. When the mixture is quite dry it is impossible to compact materials well, and the resulting mortar or concrete is porous. If a sufficient amount of water is used to produce a plastic mix the appearance is dense and uniform, while a large excess of water brings the fine particles to the surface and produces a little different texture from plastic. Moreover, the quantity of water affects somewhat the time of set of the cement and thereby to some extent the color.

PIGMENTS.—Coloring matter of various kinds can be added to the mixture. Those of a vegetable origin are not permanent because they are likely to be acted upon chemically by the ingredients of the cement. Only mineral colors should be used. The amount which can be safely used is small, owing to the danger of impairing the strength of the resulting mortar. Five per cent. by weight to that of the cement should be the limit, beyond which the impairment of strength is too great to justify a larger amount. Even this amount of certain colors which differ little from that of the cement like yellows and reds, do not produce a marked change from that of the neat cement. Lampblack is the principal ingredient used for darkening which, on account of its strong contrast and the fineness of its particles produces a strong contrast with a moderate amount. For lightening the color somewhat, lime is the best material to use. Coloring matters can be used in either a dry form or as a paste. It will generally be found most convenient for mixing to use the dry form, thoroughly mixing it with dry mortar before the addition of any water.

MOLDS.—Molds also have an influence upon the appearance to some extent. With rigid materials like metal or wood there is a tendency for the coarsest particles to come to the surface, and unless this is overcome by spading or proper manipulation, the surface is likely to be rough and porous, and if the stone is pushed too far back a mortar face is obtained. With rigid molds which are non-absorbent, the surface is likely to be of a watery appearance and after hardening will have small holes in its surface where drops of water stood and later evaporated. Porous molds, such as sand or various combinations of sand and other substances, treated or untreated with chemicals, all produce a similar effect, namely a dense cement surface, as the cement is brought to the surface by the excess water which is absorbed by the molds. However, this type of mold does not remove cement from the mortar and its surface of contact is not bonded to the casting by the excess of cement which comes to the surface. This excess of cement on the surface is liable to cause hair or map cracks and in large specimens is subject to shrinkage more than with molds of other material. If the mold is not filled by continuous pouring an unsightly line impossible to conceal later is left where work stopped.

MIXING AND PLACING.—On account of map cracking and shrinking it is not wise to mix mortar richer than one part cement to two parts sand, and for freedom from these two defects it is frequently better to mix it as lean as one to four. Stone in proper proportions can be added to the mortar to get the desired textures. Thorough uniform mixing and quick placing are desirable features. The aggregates should be graded with the utmost care to get a maximum density. A concrete whose surface has to be removed should be so made that it will have an absorption of not more than 5% by weight.

TREATMENT WHILE HARDENING.—The appearance can be modified somewhat by the treatment of the surface while hardening. If it is allowed to dry rapidly it will be of a lighter color than if kept damp and cool and allowed to dry slowly, also, the former surface will be more dusty than the latter.

Removal of Surface in Various Ways.

PICKING, SCRAPING, RUBBING (UNSKILLED LABOR).—A variety of treatment can be given to the surface by the use of unskilled labor. Taking such tools as a hand pick with a single point or a pick with a face of two inches with a series of points upon it, the surface may be scaled from the concrete, entirely removing any marks of the mold or any stains from a coating placed upon the surface of the mold to prevent adhesion of the mortar, leaving the surface below of a natural cement color and exposing the sand grains and the stone of which the concrete was composed. The cost varies considerably with the age of the cement when the picking is done. When done at the age of three or four days a laborer can cover four to five times the area he can do when the cement is two or more weeks old. The texture, however, differs. Because a larger amount of material is scaled off when the material is quite green and scaled off to varying depths, and because some particles of stone are chipped out of the surface, the texture is much coarser than when done after the cement has become hard. Under the latter conditions the surface has a fine texture and is quite uniform. A little variety can be obtained by the method in which the blow in picking is applied. By striking a perpendicular blow there is no resulting mark left on the surface by the tool, whereas with a glancing blow lines are left, and these can be made to show all parallel to one another or at various angles, and thus a little variety to the texture can be thereby given.

Another way of treating with unskilled labor is by scrubbing with water and stiff brushes, either bristle or wire brushes, while the mortar is still quite green. This removes the excess cement from the surface, obliterates the marks of the molds, and washes considerable of the cement off the surface of the aggregates, so that they appear cleaner, sometimes as clean as freshly-broken stone, and thereby obtaining a bright and pleasing effect. It is common also, in this method, to use an acid which will attack green cement rapidly and eat it from the surface of the aggregates. This type of treatment is used usually during the first 48 hours after the cement has been cast. After this age the cement resists the scrubbing and acid process to such an extent that it becomes expensive, and the best results are not obtained.

Nitric, muriatic and sulphuric acids and soap of various strengths up to the undiluted have been tried, and experience is that these agents are impracticable for the removal of vertical surfaces of *good* concrete thoroughly hardened, the action being so slow and attended with so much difficulty that hammering of one sort or another is cheaper.

Great care must be taken in successive casting to prevent marks showing (after scrubbing) where the new and old work join. The practical operation is to finish casting on some line in the building, although in certain architectural treatments this stratification is not objectionable. When it is proposed to scrub the surface of the concrete before it is more than 24 hours old, it is necessary to design the forms specially with the idea of being promptly removed without damage to the rest of the structure. This will usually save lumber, but designing for quick removal will usually add to the labor an amount sufficient to offset this. Moreover, arranging to make possible the removal of forms at certain points of the work does not necessarily get the maximum efficiency from the mixing plant, as the quantity of work may not be such as to run the plant at full efficiency for a day.

Another way of treating flat surfaces is by rubbing with pieces of limestone, water and sand, cutting away the mortar and surface of the stone, so as to expose the full cross section of the stone. This is done when the mortar is three or four days old, and is done only with the softer stones, such as marbles. This type of finish is usually known as terrazzo.

SKILLED LABOR.—The surface of concrete after it has become hard can be cut as natural stone would be cut, but this should be done by men who are experienced in stone cutting, and when treated in this way textures similar in character to those of natural stone can be obtained, in fact, the crandall, bush hammer, tooth tool, chisel and set can be used with such effect that at a short distance the appearance is identical with natural stone.

By cutting the material when green, it is impossible to get sharp corners. The round corners which are common in concrete are generally inartistic and crude in appearance. By allowing the material to become quite hard and using proper care, as sharp corners can be obtained as with natural soft stone such as limestone. It will thus be seen that the results to be accomplished have a controlling influence over methods to be used. In this way additions have been made of concrete to old buildings of natural stone with such a perfect matching of texture and color that it is impossible to tell the difference at 8 ft. distance.

It has been the experience of some engineers that just as cheap results can be obtained from bush hammering by common labor as by skilled. This, however, should be qualified again by the result to be obtained. On large surfaces where a coarse general treatment is desired and where the observer cannot get close to the surface, it can be tooled by common laborers when the material is quite soft. If, however, the observer can come within a few feet of the surface the above described treatment is not as good as cutting by skilled labor after material has become thoroughly set. A treatment which has been used to a limited extent has been splitting blocks which have been cast in a plane so as to obtain a natural fracture, and a similar effect can be obtained by breaking off pieces of the surface by a stone set to obtain a natural fracture. In this manner the natural fracture of stone is more closely imitated, but as the whole general treatment is so unnatural to a cast material it is an inartistic treatment and is not recommended.

SAND BLAST.—A finish can be obtained somewhat similar to that of scraping by means of sand blast. It is important to have the right sort of a nozzle, however, for this kind of work, and an exceedingly hard sand must be used, preferably that which has angular grains. A ½-in. diameter nozzle would produce very unsatisfactory results, because if an excess of cement came to the surface at one spot or on an edge as a joint between boards its hardness would resist the cutting of the sand while softer portions on either side would be removed, thus emphasizing the ridge. Similarly a soft spot formed by a wide

crack where the cement all ran out leaving the sand behind would be cut deeper by the large nozzle. Experience has shown that a nozzle not over ⅛-in. diameter should be used so that it can be localized on small spots and that it must be held within a few inches of the surface to be cut if there is any variation in the density or hardness of the surface.

This method leaves the stone cleaner than with scrubbing and acid treatments.

Again, the age of the mortar has a large influence upon the cost of the cutting and upon the texture of the surface. Good and economical results can be obtained when the cement is between ten and fourteen days old. It requires a fairly large job to justify the cost of setting up and operating a sand blast plant. Various building cleaning companies have portable outfits which are admirably adapted for this kind of work which can be obtained in all large cities.

CHEMICAL TREATMENT.—When the surface is chemically treated the materials used are usually commercial hydrochloric or sulphuric acid. The amount of dilution must be determined by experiment and will vary with the age of the concrete. The older the cement the stronger must the solution be. For cement which is about two weeks old ordinary commercial acid should be diluted with three parts of water. When but a few days old a dilution of one part acid to five or six of water will be sufficient. A mixture of the two acids will produce stronger action than the use of one alone. They also produce a vapor which will soften the surface when exposed to it in a confined chamber and permit removal of the surface with very little scrubbing. After the scrubbing is completed great care must be used to remove all traces of acid, otherwise there will be permanent discoloration of the surface.

TOOLS, KIND, QUALITY, TEMPER.—A new type of brush for rubbing or scrubbing green concrete surfaces which has proved very efficient in actual work is composed of ordinary wire mesh, such as fly screen, and is made by clamping together a sufficient number of sheets of wire, all of equal size, so that the exposed or rubbing edge will be at least 4 in. wide. Such a brush has proved much more effective and cheaper than the ordinary wire brush.

EFFECT OF CUTTING ON IMPERMEABILITY.—The waterproofness of concrete depends upon the density of the mortar. In the packing of mortar on surfaces which are to be exposed, greater care is usually taken in producing a dense uniform surface which would show a good appearance than in the packing of the whole mass of materials in the back. Therefore, before cutting, there is usually a dense skin of rich mortar on the surface which is practically impervious to moisture. When this is removed by any process the interior is more likely to absorb moisture than before. In one particular job where the aggregate was composed of coral sand and coral stone which was very porous, like cinders or blast furnace slag, after picking the concrete permitted water to drive straight through a 12-in. wall from a driving rain, whereas the wall previous to tooling was practically impervious. With a dense stone and quartz sand, a rich mixture, plastic consistency, well packed, a wall may be as impermeable after treatment as before. These facts are sometimes overlooked and cause unexpected and unpleasant results.

EFFECT OF CUTTING ON DURABILITY.—A wall which will absorb and hold moisture is liable to disintegrate ultimately by the action of frost. If it is impervious to moisture the action of frost is merely an attack upon the surface and is very much slower, being practically the same as on any surface of a solid natural stone. Therefore, in a cold climate, cutting off a skin to expose a porous mass is likely to somewhat impair the durability.

EFFECT OF CUTTING ON COLLECTION OF DIRT.—It is common sense to see that roughening the surface of the cement is going to permit collection of dirt and dust blowing in the streets much faster than a surface which is smooth and dense. However, as dirt and dust is usually so like the color of the cement itself it does not produce an objectionable change, and these very fine particles can lodge in the pores of the concrete and assist in rendering them more impermeable. It is only where smoke is thrown out in large volume that the smoothness of the surface must be considered to resist a change of color.

Coating Surfaces in Various Ways.

MASONRY SURFACE TO BE COVERED.—Masonry as above used includes brick, terra cotta, natural stone, concrete, mortar and plaster. The covering coat must bond to the solid material of the back and not to the dust or dirt particles on the surface and should be sufficiently substantial to hold the covering. If it is not substantial and rigid and contains cracks the surface covering is pretty sure to crack over the cracks in the back.

METAL LATH.—For outdoor purposes, it is best to use galvanized metal lath. There are various kinds, woven, welded, expanded, any one of which can be used. That having a large cross section of metal and being heavily coated with galvanizing material is likely to be the most durable, if moisture should penetrate through the plastering to this material. It should be thoroughly tied to furring at intervals not exceeding 16 ins. with galvanized wire. The furring should leave sufficient space for the mortar to push through the mesh and clinch without interference from the backing to which the furring is attached.

PREPARATION OF BASE.—The texture should be as rough as possible with recesses in the surface which will support and key on a coating which is applied, and this surface should be free from dust and dirt which would prevent the bond of union. Before coating the surface the base should be thoroughly saturated with water so as to avoid suction of moisture from the covering coat, which would impair its strength and durability.

MIXING AND PLACING.—The mixing must be thoroughly done and the amount of water used is less than with mortars or concrete packed in molds, as otherwise the mortar would run off the lath.

The first or scratch coat should be composed of one part Portland cement, three parts sand and one-half part hair putty. This hair putty should consist of long cattle hair or fiber, thoroughly worked into good lime putty. The second coat should be composed of one part Portland cement, two and one-half parts of sand and with not over 5% lime putty. The third or finishing coat should consist of one part Portland cement to two parts of sand, with not more than 5% of lime putty. (To this finishing coat may be added pebbles or other non-combustible material as may be desired to obtain a variation in the finished appearance). Where a total thickness of not more than one inch is required, it is practicable to apply it in two coats, i. e., omitting the second coat above specified. In all cases, one coat should follow the previous one as soon as it has sufficiently set to allow of so doing. This will guarantee a bond of the two applications. The finished appearance may be varied by the materials used, both as regards color and size, by the mechanical method of applying or finishing, or by a combination of any of these methods.

JOINTS.—Plastered surfaces are more subject to shrinkage cracks than monolithic work because a richer mixture is used and the thinness of the body of the material has less power to resist stress. Therefore, joints should be allowed at intervals where they will be as inconspicuous as possible, because as they are likely to occur anyway and are apt to be irregular in shape and position they are unsightly to the eye. If the surface is troweled smooth they are likely to show in an objectionable way. Unless the surface of the various coats are kept wet there is usually trouble from cracking. Some plasterers say that where the under coat is made lean with mortar and with plenty of lime and hair there is great deal less likelihood of its cracking. Care must also be taken to have a sufficient lap in the lathing; to have the lath well tied together and also to the furring so that there can be no settlement or sagging of the lath or the furring to which the lath is attached. The cracks can be filled with cement or by a pump spraying grout or run over with a tool which will fill them. They are somewhat sure to show on a smooth surface anyway.

WASHES.—Washes of cement or lime can be applied to plastered surfaces which will fill the fine cracks and give a uniform surface to the material. Washes are frequently applied to monolithic surfaces and material cast in molds and form a rather pleasing treatment when carefully and well done. If cement is applied with a brush it is not likely to give a pleasing result but is pretty sure to be streaked and irregular in color and its color is apt to be a muddy yellowish green, rather than the gray of cement. If the wash is made very thick and contains sand and is plastered onto the surface and left in this condition or else lightly troweled with a steel trowel or with wooden float the appearance will be much more uniform and of a natural cement color. This is the most usual treatment given to plain monolithic surfaces, like bridge abutments, foundations and mills in inconspicuous locations.

PAINTS.—Paint, either oil paint or special cement paints containing no oil, can be used to good advantage in painting cement surfaces either monolithic or cast, and will give pleasing appearance. The color is simply as much in the control of the designer as paints used on wood.

ENAMEL.—Enamel paints may be used on cement if there is no opportunity for water or frost to get behind the enamel, which would cause it to peel off. Enamels which are baked upon a surface cannot be used as the process of baking would dehydrate the cement and cause the mortar to crumble.

DURABILITY.—There are examples of plastered surfaces which have lasted for 15 years and are still in a perfect condition. There are numerous examples of moisture getting behind a plastered surface where this is applied to some solid back, as brick, terra cotta, stone or concrete, freezing and causing the plastered coat to peel. For this reason, plastered coat[illegible]re not generally considered as durable or as desir[illegible] as a surface treatment which is monolithic with th[illegible]dy of the surface treated. If the surface is im[illegible]eable to moisture and there is no chance for m[illegible]re to get behind the surface from any source, the [illegible]aster-ing should be durable. If it thoroughly ke[illegible] to the face its contraction and expansion will be [illegible] same as the base and therefore will not peel, d[illegible] to an unequal stress between the two materials.

Defects, Blemishes of Various Sorts [illegible]d Remedies.

RANGE OF COLORS.—The range of color in [illegible]ortar by use of pigments is limited to reds, yello[illegible] blue and black. No other satisfactory color has com[illegible] within the observation of the Committee. Red and [illegible]ellow can only be used as faint tints, as to use [illegible]m in quantities exceeding 5% by weight impairs [illegible]ously the strength. Blue shades are obtained by s[illegible] use of lampblack, and black by larger use. Th[illegible] range of color in the aggregate is limited to the colors found in natural stone or other substances as previously mentioned, which is exposed later by [illegible] removal of all cement from the surface of these [illegible]icles of aggregate.

VARIATION OF COLOR.—With the admixture of pigments, unless extremely thorough mixing is used there will be a variation in the color of the mortar. The great difficulty, however, is the variation in color between the different batches, due to a slight error in proportioning, the variation in the quality of the pigment, or the treatment during setting and hardening. Cement setting in a hot dry place will have a lighter shade than that setting slowly in a wet damp place even if all other conditions of manufacture are identical. Where the color is obtained from the aggregate, variation is due to a variable distribution through the mass or in placing an excess of stone in one part of the mass over that in another.

CRAZE, CRACKS, CHECKING.—This has been one of the most neglected subjects with which the manufacturers and users of cement has had to deal. There is little question that checking is caused by differential expansion and contraction, but years of continued and vigilant investigation has not furnished data from which definite conclusion as to the real cause of crazing in cement concrete can be obtained. The theory that cement when cured in air contracts and when cured in water expands, advanced by many, does not satisfy all the phenomena which have been observed in experiments. It is quite easy to prove that any concrete, irrespective of cement and aggregate, is never entirely free from crazing. It is well known that the greater the amount of cement the more crazing is obtained, also that careful curing greatly reduces it. With a view to bringing out discussion of this all important subject the Committee takes the liberty of appending some of the phenomena observed in experiments, and conclusion reached as follows:

1. That all Portland cement crazes. The denser the concrete the more marked are the craze lines, for the reason that it is the dirt which accumulates in same that makes them so apparent, and as the body of an absorbent concrete absorbs more of this dirt than a dense concrete but uniformly over its surface. It is only the fact that the dirt collects in the craze cracks that makes them apparent on the denser material.

2. That there is quite often an exudation from cement concrete which collects in craze cracks, which when analyzed is found to contain practically all the constituents of which Portland cement is composed, showing that more or less of this material is absorbent and carried to the surface by the moisture when the concrete dries.

3. Exposure of green concrete to drafts, sun and rain, appreciably increases the amount of checking, but that no matter how carefully concrete is protected or for how long a period, it will eventually craze and check on exposure. This has been proved by curing concrete in water kept at very nearly a constant temperature for a period of two years, and that casts so made when sawed in half thoroughly dried out, and exposed to the air, checked inside of 30 days.

4. That such crazing or checking is not confined entirely to the surface of concrete.

5. That the addition of waterproofing compound does not stop checking, but by the preventing of concrete absorbing dust and dirt prevents it from showing temporarily.

6. That a thorough mix and proportioning of the aggregate so as to reduce the amount of cement necessary to make a dense concrete, materially decreases checking.

EXPANSION AND CONTRACTION CRACKS.—Such cracks are due almost entirely to thermal stresses and can be overcome and controlled by proper reinforcement with steel in lengths of concrete up to 500 ft. and perhaps longer, but as such would be treated under the subject of concrete design.

HORIZONTAL JOINT.—In building monolithic walls where work is stopped for the day, an excess of mortar

frequently tamped to the surface and sets. The following day when soft concrete is added an excess stone settles through the mortar to the hard surface below so that after cutting the surface a line is shown about ½-in. wide of mortar with an excess of stone directly above. This is avoided by scraping ½-in. of the surface when the day's work is done before this has had time to set and by care in using stiff mix in the first batch deposited next day so that the stone is held uniformly distributed in the mortar which is too stiff to permit the stone to settle through it.

PATCHES A DARKER COLOR.—These seem to be caused by using a richer mixture, steel rubbed off from trowel with which applied, less surface evaporation

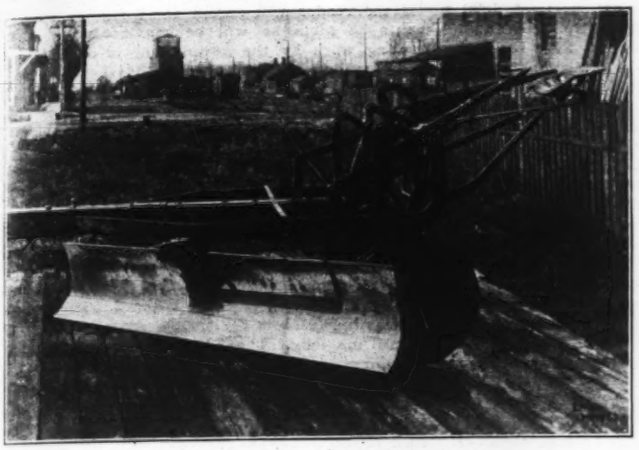

FIG. 1. THE "20TH CENTURY" GRADING MACHINE.
Baker Mfg. Co., Chicago, Builders.

from patches, or bringing to surface by troweling of the dark colored cement particles of the aggregates. It has been conclusively demonstrated that with due care and by addition frequently of some material to lighten the color of material put into a patch, that the patch cannot be detected even after several years of exposure.

EFFLORESCENCE.—Efflorescence is caused almost exclusively by percolation of moisture through a wall. It is not to be observed where a wall is always dry. Portland cement always contains some free lime and this is brought to the surface in solution by water and left there by its evaporation. This efflorescence has been chemically analyzed and found to be almost pure carbonate of lime. The remedy is to avoid percolation of water through a wall. If this tendency is very slight, as for instance in the wall of a building which is somewhat porous, allowing a driving storm to soak into the surface in such quantities as to later percolate to the surface bringing with it in solution lime, the appearance of efflorescence can be very much reduced or practically removed by waterproofing the surface with some compound which will prevent all absorption and percolation whatsoever.

FROZEN SURFACES.—Freezing retards the setting of cement but does not destroy it. If the surface freezes the set is retarded so that the portion behind which is not frozen, setting faster, breaks the bond between the two, causing the frozen portion to scale. The remedy after the surface is frozen where the material lost has not got to be replaced, is to re-surface that material which is left. If it must be replaced the texture of the surface originally desired must determine largely the method of treatment. If this be a plastered surface it is a simple matter to roughen up the back to give a key for plaster and to place it on. If it is to be a tooled concrete surface, then a sufficient mass must be removed to enable a new facing to be placed, including aggregate of the same size and proportions as in the original work, in order to build out the face and also to have sufficient strength and stability either to stand by itself or to be properly keyed by suitable methods like the use of reinforcement, to the back.

DUSTING.—These troubles are due to soft sand, unsuitable foreign material in sand, too little cement in mixture, bad mixing, too much time elapsing between mixing and finishing, finishing mixture too dry or too wet, use of "dryers" (i. e., dry cement with or without sand to dry out the surface so that it can be quickly finished), permitting the surface to dry so rapidly as to impair the setting of the cement. When a thin surface is placed on one which has become hard there is liable to be dusting because there is no absorption from the concrete to take care of the excess moisture in the mortar. It has therefore got to come to the surface and in so doing it brings the soluble salts of Portland cement called laitance with it and some of the finest particles of the cement, the impalpable powder, to the surface, both of which are easily brushed off, and thirdly, because the moisture comes to the surface it cannot be troweled as soon as it ought to be, and when it is troweled so long a time has elapsed that the setting of the cement is broken up or impaired, thus materially reducing its strength. The remedy, where color is not an object, is the application of one or two coats of well boiled linseed oil. Paint is sometimes used, but is not a satisfactory material because as a rule it does not harden the dusty surface and the dust prevents its bonding to the mass below so that it scales off, leaving an unattractive appearance. In some cases the top may be ground off as in terrazzo work, until a hard surface is obtained.

Costs.

COSTS.—The cost of unskilled labor for picking or rubbing concrete when 6 to 24 hours old is about 1 ct. per sq. ft. If two days old, so that fiber brushes and water have to be used the cost runs from 2 to 3 cts. for actual dressing of the surface. In order to be able to remove the forms to get at the surface at these ages it will have to be designed in such a way that its price may vary from nothing to 5 cts. per sq. ft.

For a special facing material 1 in. thick of one cement, one and one-half sand and two and one-half of fine crushed stone or pebbles, placed at the same time with a coarse backing in the walls, will add about 3½ cts. per sq. ft. to the cost of the surface. This cost is independent of the method of treating the surface later.

Tooling by multiple picks by common labor when the surface is green will cost from 3 to 4 cts. per sq. ft.; when hard, from 5 to 10 cts.

The cost of the use of pneumatic tools varies materially with the size of the job and to what extent the work is scattered. For long low walls pneumatic tools will cost more than hand. For large areas like the soffit of a big arch pneumatic tools will be cheaper than hand work by one-half to one-third.

Sand blasting when the cement is one to two weeks old will cost about the same as bush hammering; when older it will cost considerably more.

Extended experience gives the following cost data: For hand tooled cast concrete four or six grooves to the inch with steel tools, the cost on a contract of tooling some 10,000 sq. ft., with skilled labor, was 15 cts. per sq. ft.; the same kind of tooling with pneumatic tools about 12 cts.; the same tooling done in a factory by grinding with a special designed machine, 1 ct. This special designed machine consists of cutting wheels suspended on an arm like a pendulum wood-working saw revolved at a high rate of speed, so that concrete of almost any age could be cut without disturbing the stone in the aggregate. The cost of crandalling, being an average of many jobs, with skilled labor, is about 10 cts.; with unskilled, about 5 cts.

A Light and Handy Grading Machine.

There are many jobs of grading work for which machine work is desirable on the ground of rapidity and economy, but on which the ordinary large grading machine cannot be used to advantage. Thus in the repaving of streets it is often necessary to excavate to a new subgrade in order to provide sufficient depth for a concrete base. This is slow work with hand shoveling, but the length of the street opening (perhaps limited to one block to avoid interference with intersecting streets) and the comparatively light cut make the job ill adapted for handling with an ordinary grader and teams of horses.

A light and compact grading machine devised for work of this kind is mounted on two wheels, drawn by two horses and operated by one man. Such a machine, termed the "20th Century Grader," is built by the Baker Mfg. Co., of Chicago, and has been used recently in the regrading and paving of streets in the congested downtown district in that city. A general view of the machine is shown in Fig. 1, while Fig. 2 shows it in use in preparing the new grade for concrete foundation on Monroe St., Chicago.

A light steel frame supports the attachments for a scraper blade or mold-board of the usual form (6 ft. or 7 ft. in length), and for the levers by which the position of the blade is regulated. One lever adjusts the blade to any desired height, while the others raise and lower the ends of the blade so as to give it any desired inclination from the horizontal. The back of the blade is attached to a segmental bar having holes to fit a vertical pin which passes through a hole in the tongue, so that the blade can be set at any desired angle with the frame. It is reversible and may be adjusted to a maximum of 45° on either side of the center line. To the frame is attached the timber tongue to which the horses are harnessed, and the rear end of the frame is supported by two wheels 16 ins. diameter and 3½ ins. wide. A special feature of the wheels is that each has an outside flange 2 ins. deep, formed by a steel disk 20 ins. diameter. These flanges sink into the earth and help to hold the machine up to its work, but they can be removed when the machine is to be used for such work as removing snow or dirt from paved streets.

Each end of the mold-board has a shoe (adjustable vertically) which holds it in position and has (like the wheel) a flange to afford resistance against the pressure of the earth against the blade. The shoes also prevent the blade from cutting too deep.

The weight of the machine complete is about 600 lbs. It is drawn usually by two horses, but in heavy material four horses may be used. The driver rides on the machine and the operating levers are convenient to his hands, but where frequent turns are made (as on a short stretch of street), a helper walks with the machine to raise the blade promptly at the end of the travel and lower it again when in position for the return. This leaves the driver free to give attention to his team in making the sharp turns on a rough surface.

The machine is adaptable to a great variety of grading work. It has been used for grading roads, railways and canals, scraping roads, spreading broken stone, leveling fields and lawns, excavating and cleaning drainage and irrigation ditches, etc. On drainage work in Illinois it has been used to grade to proper form a levee built by dumping material from a dipper dredge. This

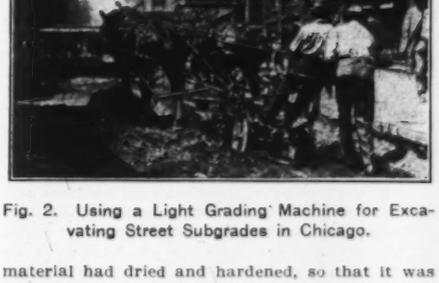

Fig. 2. Using a Light Grading Machine for Excavating Street Subgrades in Chicago.

material had dried and hardened, so that it was necessary to first plow the rough and irregular surface in order to form a path for the grader team. The grading machine was then used to level the top and form the side slopes. The machine can be used as a scraper by placing the mold-board at right angles to the frame and fitting a wing at each end, while for grubbing, a heavy cutter can be attached in place of the mold-board. In addition to these various purposes, the machine has been used in several large cities for the removal of snow, scraping the snow into winrows ready for loading into wagons. Smaller towns have used it for clearing snow from sidewalks.

The Leveling Operations of the United States Government.

By E. M. DOUGLAS, M. Am. Soc. C. E.*

There are few persons that realize or even know of the great amount of engineering work carried on by the United States Government which may be made of direct use by the public. Most people, because of their ignorance of the facts, consider government documents as no better than so much waste paper, yet if any engineer about to undertake some public works (such as those for irrigation, drainage, stream gaging, land surveying, road or railway location) would take the trouble to inquire of the proper bureau he would doubtless secure publications or data of great value to him. The Superintendent of Documents, at Washington, D. C., sends out free, on request, catalogs by subjects of government publications, with prices for such as he has in stock, but many of those listed can be obtained free of cost by applying to a member of Congress or to the bureau which issued it. The price charges for those that are sold cover only actual cost of paper and printing.

FIG. 1. BENCHMARK TABLET USED BY THE U. S. GEOLOGICAL SURVEY.
(Made of cast aluminum, aluminum bronze or brass. The name of the state is omitted in non-cooperating states.)

It is the purpose of this article to call particular attention to the spirit leveling executed by various government departments. Exact figures for the total number of miles of line run are not available, but the reports of the U. S. Geological Survey show that since 1897, when such work was authorized by Congress, there have been run over 200,000 miles by that bureau alone. In connection with which more than 24,000 substantial metal bench marks have been established. The leveling by the Corps of Engineers, U. S. Army, along the Mississippi and Missouri rivers amounts to over 5,000 miles. The Lake Survey in connection with its work has run nearly 1,000 miles; the Coast and Geodetic Survey more than 13,000, and the Reclamation Service and other bureaus add to the total, so that in all there have been not less than 225,000 miles of line run from which accurate elevations have been determined for more than 30,000 bench marks on stone or metal. The published results of this work can be depended on; the lines are so checked and tied one with another that it is practically impossible for a dishonest levelman to "fudge" his notes, or by careless work to render them useless.

The work by the Coast and Geodetic Survey is as accurate as modern instruments and the most refined methods can make it; none better is done anywhere on earth. In reducing and adjusting the results, allowance is made for factors which the ordinary engineer never thinks of. The leveling† instruments are made of a nickel-steel alloy which has less than 1-20 the expansion of ordinary steel or brass and besides the instrument is shaded when in use. The rods are of pine, soaked in paraffine to prevent trouble from moisture. They are tested before they are used and after each line is finished, and allowance made not only for rod error but for expansion as computed from the observed temperatures. Allowance is made for errors due to curvature of the earth in unequal sights which at times are unavoidable. Allowance is also made for the differences in curvature between north and south lines and east and west lines. Accurate data regarding speed, cost and methods of work are given in the publications of the bureau, which can be secured through members of Congress or consulted in any large public library. Of particular interest are the Annual Report of 1899, Appendix No. 8; Annual Report of 1903, Appendix No. 3; Annual Report of 1905, Appendix No. 4, and a special publication on leveling published in 1900.

The work by the Geological Survey is primarily intended for the control of its topographic maps, yet for all its long lines it now uses the Coast and Geodetic Survey style of instruments, the general methods* are modified to suit its special needs and the results approach closely if they do not equal those of the other bureau. The standard leveling by the Geological Survey is carried on with 20-in. wye levels having extra sensitive bubbles, giving results of a high grade of accuracy being probably better than the best work of the kind executed by railroad engineers. The permissible error in circuit closures for such work is, however, several times greater than is allowable for the precise lines and is in feet = $0.05 \sqrt{\text{distance in miles}}$.

The work of the Army engineers is with a different type of level and by somewhat less accurate methods than those now used by the Coast and Geodetic Survey, yet it is of a very high standard.

It has been found in recent work of the Coast and Geodetic Survey that the average error per mile run is 0.0036-ft., or about 1/25-in., but since in first-class work such errors tend to balance, the actual resulting errors are extremely small. For example, the Coast and Geodetic Survey has a continuous line from Sandy Hook, N. J., to Seattle, Wash., about 4,800† miles. From Cheyenne, Wyo., eastward, there are closed circuits thus affording an adjustment for the elevation of the benchmark at that place. From Cheyenne to Seattle, nearly 1,500 miles, there is not yet an adjusted circuit. The adjusted elevation of Cheyenne carried westward closed on mean sea level at Seattle only 0.615-ft. in error, or about 7⅜ ins. There has recently been completed by the same Survey a line from the Pacific Ocean via Needles, Cal., Ashfork and Flagstaff, Ariz., to Albuquerque, N. Mex. At Ashfork and Williams it connects with Geological Survey benchmarks on a precise line from Williams via Ashfork and Phoenix, Ariz., and Deming, N. Mex. to Albuquerque, thus making with the combined work of the two surveys a loop of 1,150 miles. Between Williams and Ashfork (23 miles) the two lines differ 0.013-ft., between Ashfork and Albuquerque they differ 0.549 ft. Many other equally surprising closures could be given.

Poor results by either of these organizations when discovered are checked by new field work if practicable, but when that cannot be done they are either discarded or, if published, are given for what they are worth. The errors most to be feared in good work of any kind are blunders such as at times are made by everyone, and leveling in particular emphasizes the importance of never depending on the work of an individual however skilled or careful he may be that does not have a check independent of his control. The blunders of levelmen to be looked out for with greatest care are errors of even units, or tens of units, foot, meter, or yard. [illegible] the Cheyenne-Seattle line the Coast and Geodetic Survey carried forward for a long distance an error of ten meters which possibly might not have been discovered had there not been a check on the results. It has cost the Geological Survey hundreds of dollars to locate errors in a single unit and in one case great trouble was caused by a hundred-foot error.

If the reader will accept the foregoing statements as facts he will be convinced that the leveling work by the government is as reliable as human effort can make it. How, then, can the results be obtained and made use of?

The Coast and Geodetic Survey confines its inland work to long lines. The Geological Survey runs its lines over all areas topographically mapped or which it is proposed to map in the near future, as it is required by law to establish one or more benchmarks in each 36 sq. mi. surveyed. It is now a rule of that Survey to establish one benchmark of metal for each five miles of single line run.

The benchmarks used by the Geological Survey are illustrated in Figs. 1 and 2. The tablet shown in Fig. 1 is 3¾ ins. in diameter with a stem 3 ins. long. These have been cast of brass, aluminum, and lately of aluminum bronze (10% Al. 90% Cu.) and cost complete from 30 to 45 cts. each. They are used whenever substantial masonry structures, large boulders, solid rock, rock or cement posts are available, being fastened in drill holes with Portland cement. Of these over 5,000 have been established in the past 13 years. The iron posts (Fig. 2) designed by the writer, are 4 ft. in length and 3½ ins. outside diameter and have a brass or aluminum bronze cap riveted on the top. Of these over 20,000 have been used. They cost at the present time $1.90 each f. o. b. St. Louis. These are set where the tablets cannot be used and in important localities are often set on a concrete base or are surrounded by concrete. They are so placed as to project from 6 ins. to a foot above the surface of the ground. For popular information the levelman stamps with steel dies on each mark (post or tablet) the elevation as then determined by him to the nearest foot. These figures aid in identifying the mark, but since the level-

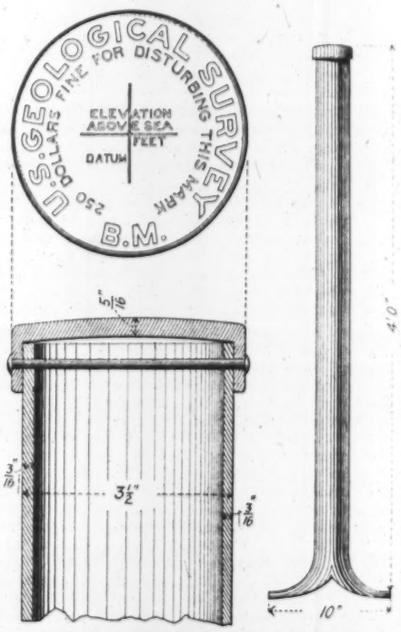

Fig. 2. Benchmark Post Used by the U. S. Geological Survey.
(Made of iron. In areas where the state pays half of the expense of the field work the words "In cooperation with the State of ————" are added.)

*Geographer, U. S. Geological Survey, Washington, D. C.

†See an article in Engineering News of July 2, 1903, by J. W. Hayford, describing the latest type of level used.

*See an article by the writer in Engineering News for May 17, 1906.

†This is not by the direct route but is by level lines of the highest grade of accuracy.

man's computation have not been checked nor any adjustment of circuits made the figures as clamped are often in error by a foot or more. Consequently anyone having occasion to refer to one of the benchmarks should ascertain from the Washington office of the Survey its adjusted elevation.

The Coast and Geodetic Survey uses benchmarks similar to those illustrated, but more generally, in masonry or solid rock, it uses the bottom of a hole about an inch square by a quarter inch deep cut into the rock around which are the letters U. S. B. M. It also uses ⅝-in. copper bolts leaded into stone or masonry structures. The Coast and Geodetic Survey never stamps figures of elevation on its benchmarks. Its lists and descriptions are published in annual reports, notably 1899, 1903, 1905 and in a special publication in 1909, previously referred to. In addition to the regular benchmarks both of these Surveys determine and publish thousands of secondary elevations: such as top of rail in front of each railroad station passed, surface of water in lakes or rivers, well defined marks on highways or railroad bridges. They also aim to connect whenever practicable with benchmarks of other organizations, such as those of cities, railways, etc. The Army engineers use stone or iron posts, the reference points for the latter have in the past been on a pin in a tile or stone underneath the post. Some posts of the Geological Survey style have also been used.

When sufficient data have been secured for a given state to warrant a special publication the Geological Survey gives its work for the state in book form, but until they are thus published the results are given in some sort of annual report or, in advance of such publication, typewritten lists are prepared for the various localities of work and given freely to any person who shows that he will make use of them and is not asking for them out of idle curiosity. The Army engineers publish their results in pamphlet form and in annual reports.

The country is even now fairly well covered with government level lines and they are being added to at the rate of from 6,000 to 10,000 miles per annum. There are probably but few areas in the United States that are any considerable distance from a well-established government benchmark, and any engineer having occasion to use such data would do well to inquire of one of the government bureaus for description and elevation of the nearest marks.

Forest Fire Protection By New York State.

The protection of New York forests from fire was one of the subjects discussed by Hon. J. S. Whipple, Forest, Fish and Game Commissioner, at the National Conservation Congress, St. Paul, Minn., Sept. 7, 1910. Mr. Whipple stated as an introduction to his address that of the total area of the state (50,203 sq. miles, or 32,129,920 acres) 27% is occupied by forests, or nearly the same percentage as the forest area of Germany. The state owns a total of 1,641,526 acres, "one-third of which is virgin forest or that which is now equally good."

[We have learned through Mr. G. A. Whipple, Secretary to Commissioner Whipple, that of the State land just named 1,530,562 acres is located in the Adirondack Park and 110,964 acres in the Catskill Park. The total area of each park is 3,313,564 and 576,120 acres, respectively.—Ed.]

The significance of fire losses and means for their prevention which have been adopted in New York State were thus set forth in the address:

Some people do not understand the great danger of total forest destruction threatening certain of our watersheds. It takes fifty to a hundred years to grow a mature tree. The average soil increases about one inch in a century. It requires soil to grow trees, and fire, the great enemy of the forest, destroys not only the trees but the soil as well. On two or three occasions in the past seven years the Adirondack Park has come dangerously near being wiped out by fire. Rain alone has saved it. In 1903 and again in 1908 several large fires burning at the same time threatened to unite and destroy the entire park. No human agency can combat successfully a great forest conflagration when once it is under way. One hundred and seventy-seven thousand acres of land was burned in 1908 in New York State. The loss approximated $844,000. In 1903, 500,500 acres were burned and the loss was more than a million dollars. Loss of soil and reproduction was not considered in the estimated loss and never is.

It is logically evident from the history of forest fires that prevention is the right objective in seeking to remedy this great evil. Methods of protection after a fire starts will fail when certain commonly occurring weather conditions prevail. In New York we have devised an effective forest fire fighting organization based upon the principles of prevention. The Adirondack and Catskill sections have been divided into four districts, three in the Adirondacks and one in the Catskills. A superintendent was appointed to take charge of each district. Under him there were assigned regular patrolmen and special patrolmen, and to a certain extent the superintendent cooperates with supervisors of towns. The aggregate number of men engaged in this work this year is 262. In addition to this the supervisors in every town in the State of New York are responsible personally for damages caused by forest fires in their respective towns if they are negligent in putting them out.

I met the Boards of Supervisors of the various Forest Preserve counties and discussed with them ways and means of fighting fire, explaining the law and showing their responsibility. This action was followed by good results. The superintendents were in turn assembled at Albany and properly instructed as to their duties and the relationships to be carried on between their subordinates and themselves. Twenty observation stations were erected on high points and equipped with strong field glasses, range finders, maps and telephones. The whole territory has been covered with telephone lines. These stations have proved an incalculable benefit in the apprehension of fires when they are in an incipient state. We have also added to the fire fighting apparatus portable fire extinguishers. These are very useful in checking a fire at the beginning. Old trails and tote roads are kept clear of obstructions to make the woods more accessible. The whole system is chiefly valuable in that it is based upon the fundamental principles of early discovery, immediate alarm and prompt action. Over 250 fires were discovered and extinguished last year so quickly that they attracted no public notice and the damage done was unappreciable.

Another step was taken by the Forest, Fish and Game Commission when the question of oil-burning locomotives running through the Forest Preserve was called to the attention of the Public Service Commission. After an exhaustive investigation, oil as fuel was substituted for coal by order of the public Service Board. This order required that the railroads should install oil-burning engines for use between 8 a. m. and 8 p. m., from April 15 to Nov. 1 each year, all engines to be inspected by representatives of the Commission. Coal-burning locomotives still run through the Forest Preserve at night which, on account of the heavy dew, it is thought in most seasons does not materially increase the fire risk; but it is doubtful whether in an extremely dry season coal-burning locomotives would not set fires at night as readily as they do during the daytime. The partially restricted use of coal as fuel was the best change obtainable at the time the order was promulgated.

The third factor contributing to reduce fire danger was the provision of the new law requiring the lopping of tops of all coniferous trees felled in the Forest Preserve. The value of this provision is realized when it is understood that the tops of trees felled a decade ago, when not lopped, are still ready to burn, while the debris of lopped trees disappears entirely as a fire menace in the same period of time because they lie flat on the ground, absorb moisture and rapidly decay.

A DERAILMENT AT HIGH SPEED wrecked the Cherbourg-Paris express at Bernay, France, Sept. 10. According to press reports, seven persons were killed and about 50 injured.

THE FUEL OIL SYSTEM OF THE "NORTH DAkota," first-class battleship of the U. S. Navy, was damaged by an explosion and fire Sept. 8. The accident occurred in lower Chesapeake Bay. The cause of the explosion, which killed three men outright and injured eight or nine others, has not yet been ascertained. Reports state that at the time of the accident, a test was under way on the fuel oil apparatus, which supplements the regular grates under the battleship's boilers.

RAILWAY TRAFFIC ACROSS BROOKLYN BRIDGE, New York City, was tied up for three hours in the evening rush period on Sept. 13. The primary cause was a short circuit of a conductor rail of the elevated railway tracks through either a defective contact shoe or displaced insulators. Before the circuit breaker of the feeder to this section of third rail opened, the feeder insulation caught fire in an elevated control tower and caused a secondary short circuit. Some 20 minutes' delay followed in opening the circuits at the power-house, and by that time the board controlling the electro-pneumatic track switches was destroyed. About this time the trolley pole of a bridge surface car broke and stalled the car so that surface traffic also was blocked for an hour. This complete tie-up threw such crowds to the subway that its Brooklyn schedule was badly disarranged for several hours.

A RAILWAY CAR FERRY SANK in Lake Michigan Sept. 9, and 28 of the 62 persons on board were killed. The car ferry was the Pere Marquette R. R. Co.'s No. 18. She left Ludington, Mich., at 11:30 p. m., Sept. 8, bound for Milwaukee, Wis., with 29 loaded freight cars on board. Early the following morning it was found that water was entering the rear compartment of the hold at a rate greater than the capacity of the pumps. The ferry was headed for the Wisconsin shore, many miles distant, nine cars were pushed overboard in the effort to lighten ship, and help was summoned by means of wireless telegraphy. Pere Marquette ferry No. 18 soon reached the sinking vessel, but as no immediate danger was anticipated, she merely stood by. Suddenly, however, No. 18 sank rapidly, stern first. Many on board who might otherwise have escaped were struck by wreckage from the roof of the cabin which was burst open as the vessel went under.

A FALL OF ROCK at the west portal of the old Bergen Hill tunnel of the Erie R. R., just outside of Jersey City, on Sept. 11, caused the death of 12 workmen and seriously injured a number of others. Under this hill the railroad has just completed a four-track tunnel and open-cut alongside of but slightly above the old two-track tunnel which has always carried the tracks through to Jersey City. At the west portal the old and new lines emerge from the hill immediately adjacent to each other and at this point an open cut is being made which includes the track area of both old tunnel and new open cut. To do this the arch and walls of the old tunnel had to be broken down for a distance of about 170 ft. back from the west portal. This tunnel is a 5-layer brick arch through the Hudson River trap rock common to this section. Breaking had been carried on from the new and the old portals toward the middle of the 170-ft. section, so that on the day of the accident there remained only a 20-ft. length of the arch left, overtopped with about 6 ft. of loose rock which had been broken down and which the workmen were removing. Another gang was preparing the holes for the shots which were to be used to drive down this small remaining length of arch. At the side of the arch toward the new open cut there was a wall of trap rock some 18 ft. high left to protect the trains in the cut.

The collapse was sudden and came without warning, carrying all the men who were on top of the arch down into the tunnel. Whether it was due to the failure of the arch ring from the heavy load of non-cohesive rock upon it or to the slide of a portion of the 18-ft. adjacent trap rock wall has not been determined as yet. The arch ring was of good brick laid up in strong mortar and had not failed or shown a disposition to fail in the other portions of the length broken down. The face of the 18-ft. wall that remains is smooth and nearly vertical as though there had been a seam there, from which a portion of the face had slid off.

PANAMA CANAL EXCAVATION during the month of August totalled 2,813,462 cu. yds. for the 27 working days, a daily average of 104,202 cu. yds. During the month 146,553 cu. yds. of concrete were laid and 652,514 cu. yds. of fill placed. Rainfall for August was 11.61 ins., a slight decrease from July.

A RECORD for duration of aeroplane flight of 3 hrs. 4 min. 44 sec. was established by Ralph Johnstone, in a Wright biplane flyer, on Sept. 12 at the Squantum aviation meet near Boston.

A new height record (uncorrected) of 8,792 ft. was made by one George Chavez with a Bleriot monoplane flyer, at Issy, France, on Sept. 8.

A HIGH-TENSION TRANSMISSION-LINE crossing is projected by the Canadian Light & Power Co. over the St. Lawrence River at the head of the Lachine Rapids and about 600 ft. below the Victoria bridge, in connection with the hydro-electric development at St. Timothee, P. Q. The proposed development was noted in Engineering News, Sept. 23, 1909, p. 329. There are to be two piers in midstream for one tower of the transmission-line crossing, each having an extreme length of 67 ft. and a width of 15 ft. 6 ins., together with four smaller piers for each of the two land towers. The total spans of the cables, between these three piers, will be 1,600 and 1,800 ft., respectively. The towers are to be of structural steel, and will have a height of 135 ft. above the tops of the piers. The contract for the construction of the piers and the erection of the towers has been let to The Foundation Co., Ltd., of Montreal. Plans for the work have not been announced beyond the statement that on account of swift current and deep water, most of the plant for the midstream piers will be mounted on barges. As a difference of 15 ft. is recorded between high-water and mean-tide levels, and as in spring there are numerous heavy ice floes, it is stated that the work must be carried on with extreme rapidity.

U. S. TORPEDO BOAT DESTROYER SPEEDS have been incorrectly reported by the press, according to Admiral H. I. Cone, Engineer-in-Chief, U. S. N. In our issues of Sept. 16, 1909, p. 313; Oct. 14, 1909, p. 400, and April 14, 1910, p. 447, we printed notes to the effect that the "Reid" first had made a mile at a 34.548-knot speed and later had made a four-hour run at a 36-knot speed; that her sister ship, the "Flusser," had an initial record of 33.7 knots for the mile and a later record of 35 knots for the four-hour run. These records we published on the authority of press reports which we now find to be much exaggerated. According to Rear-Admiral Cone the fastest four-hour trial ever made by a United States war vessel was by the torpedo-boat destroyer "Paulding," likewise of the "Reid" and "Flusser" class.

The "Paulding," on her preliminary acceptance trial, averaged 32.801 knots for four hours. The highest speeds for four hours ever made by the "Flusser" and "Reid" were, respectively, 30.41 knots and 31.82 knots, made on their preliminary acceptance trials. The best speeds of these three vessels for one mile (average of five high runs on standardization trials) were: "Paulding," 33.064 knots; "Flusser," 32,663 knots; "Reid," 33.780 knots. On their final acceptance trials (after 6 months' service) the latter two vessels did not exceed their former trial speeds.

AUTOMOBILE FIRE APPARATUS was the subject of papers read by two municipal fire-department chiefs before the recent International Association of Fire Engineers at Syracuse, N. Y. Both men, Charles S. Allen, of Trenton, N. J., and Frederick G. Reynolds, of Augusta, Ga., were enthusiastic over the advantages of the automobile fire-engine. Its points of superiority over the horse-drawn, steam fire-engine, as given in their papers, may be summarized as follows: (1) Higher speed. (2) Lower operating cost. (3) Better progress on steep grades and through snow drifts. (4) Instant availability of full pumping power upon reaching the fire.

Chief Allen, of Trenton, gave figures on comparative costs of supplies and repairs for an automobile and a horse-drawn engine company, covering a period of ten months. Supplies and repairs for the auto company were less than for the other company by about $735. The additional saving of the salaries of two men brought the total in favor of the auto company up to $3,094 for the ten months. The auto fire-engines are arranged to carry their own hose: thus the services of both a hose-cart driver and an engineer are dispensed with. Chief Allen stated that better service was obtained with seven men in the auto company than from the nine men of the engine company.

CHOLERA IN RUSSIA for the week ending Sept. 3 resulted in 9,899 cases and 4,405 deaths, which was a decline of about one-third from the previous week. For the whole season, 170,363 cases and 77,446 deaths have been recorded. We find these significant statements in an Associated Press dispatch:

The Armenian clergymen of Erivan held a procession with the sacred image through the city beseeching that the plague be stayed. The shops were closed and the entire population participated.

The epidemic has made greater progress in remote villages, for instance in the province of Tamboy where over 200 localities are stricken. The mortality in the villages is greater because the peasants persist in an attitude of hostility toward the physicians and nurses. A doctor was killed in Yekaterinoslav province and reports of medical men being beaten are constantly received by the sanitary bureau. It is necessary for the physicians to be escorted by gendarmes. Reactionary demagogues in many parts of Southern Russia incite the population against the medical attendants and the Jews, declaring them to be agents of the plague.

That the disease is by no means confined to Southern Russia or to remote villages is shown by the statement that since June 20 there have been 3,188 cases and 1,107 deaths in St. Petersburg, the capitol of the empire.

A NEW YORK TO PHILADELPHIA SHIP CANAL, one of the leading projects advocated by the inland waterways enthusiasts, has just been reported upon by the U. S. Army Engineers. Last year the Federal Congress authorized a survey to find "a practical route between deep water in New York bay and deep water in Delaware bay, which does not cross any trunk line "railroad." Col. W. M. Black, Corps of Engineers, U. S. A., has presented the results of that survey. It is reported that a route has been found that answers the requirements but on account of the possible effect on real estate speculation, it is not given out. The report says in part:

A practicable route between deep water in New York bay and deep water in the Delaware river has been found which does not cross any trunk line of railroad. Three branch lines are crossed. For the most important of the three, the railroad can cross at an elevation of 110 ft. above the canal surface. The other two can be carried over the canal so as to leave a clear height for shipping of 15 ft. No fixed bridges are projected.

The distance from the Battery in New York city to the wharves at Philadelphia is about 80 miles. Of this distance 25 miles will be through the open waters of New York bay, 30 miles across the state of New Jersey and 25 miles through an improved channel in the Delaware river. Allowing a speed of 15 miles per hour for the New York bay and Delaware river sections and nine miles for the inland section, we have a transit time of about seven hours for a sea level canal, and about nine hours for a lock canal.

Approximate estimates of cost have been made over this route for a sea-level canal and for one having its summit level at 170 ft. above mean low water, with a flight of two locks of 35 ft. lift each at either end.

The cost of these two projects, considering capitalization, is so nearly the same that a choice between them involves the question of adaptability to the needs of commerce rather than cost of construction.

These costs, that is first cost plus annual maintenance capitalized at 4%, vary from $38,725,000 for a lock canal, 70 ft. summit, 125 ft. bottom width and an 18 ft. depth, to $53,632,000 for a sea level canal with bottom width of 200 ft. and a 25 ft. depth.

It is understood that the following Congress will see a great effort to procure an authorization of this project.

THE LARGEST DRY-DOCK IN THE WORLD is projected by the Mersey Docks and Harbor Board at Liverpool, England. The dock is planned of a size to accommodate the huge White Star steamers now approaching completion and also the new Hamburg-American ship and the mammoth vessels which the Cunard Co. is said to be considering. The structure is unique, however, in being intended for use ordinarily as a wet dock and it will only be pumped out when some huge vessel demands the use of the dock. It may be explained that on account of the great variation in the tide at Liverpool, steamers of all kinds lie in enclosed docks while receiving and discharging cargo, the gates of these docks being opened for ingress and egress only at mean tide.

The new structure, which has been christened the Gladstone Dock, is being planned by Mr. A. G. Lyster, the Board's engineer. The dock is to have a total length of 1,020 ft. with an entrance 120 ft. wide. A single story freight shed will be built on one side of the dock, 100 ft. wide and 900 ft. long with four 1½-ton traveling cranes running the whole length of the dock. The total cost of the dock and appurtenances is set at $2,500,000.

Personals.

Mr. Newman Erb has been elected President of the Chattanooga Southern R. R.

Mr. E. N. Brown, President of the National Rys. of Mexico, has become also President of the Pan-American R. R.

Mr. Lucius Tuttle has resigned on account of ill health the presidency of the Boston & Maine R. R., which he had held for 17 years. Mr. Charles S. Mellen is at present Acting President.

Mr. A. T. Ewell, recently Engineer and Inspector for the Seaboard Air Line Ry., has resigned and is now Assistant Locating Engineer on the Allagash extension of the Bangor & Aroostook R. R.

Mr. Morris Knowles, M. Am. Soc. C. E., M. Am. Soc. M. E., recently Chief Engineer of the Pittsburg Bureau of Filtration, has opened offices for the practice of general civil engineering in the Oliver Bldg., Pittsburg, Pa.

Mr. D. E. Williams and Mr. J. N. Hannum have formed a partnership for the practice of general structural engineering under the firm name of Williams & Hannum, with offices in the Schofield Bldg., Cleveland Ohio.

Mr. Ira G. Hedrick, M. Am. Soc. C. E., and Mr. Victor H. Cochrane, Assoc. M. Am. Soc. C. E., have formed a partnership for the practice of consulting engineering under the firm name of Hedrick & Cochrane, with offices at 1118 McGee St., Kansas City, Mo. Mr. Cochrane was formerly Assistant Engineer for the firm of Waddell & Harrington.

Mr. E. B. Rogers, formerly Manager for the Bell telephone system in charge of exchanges in the southern part of New York State, has been appointed Chief of the Division of Telephones and Telegraphs of the New York Public Service Commission, Second District. Mr. Rogers' headquarters will be at Albany, N. Y., but an assistant under him will have charge of the New York City office at 1 Madison Ave. Information in regard to the Division of Telephones and Telegraphs was published in our issue of Sept. 8, p. 265.

Mr. Charles Saville, who for five years previous to May, 1910, was connected with the Engineering Department of the Massachusetts State Board of Health, latterly as assistant engineer, has begun a year's engagement with the Abwasserabteilung der Emschergenossenshaft in the capacity of "Diplom Ingenieur." The Emschergenossenshaft has charge of the design, construction and operation of the sewerage system and sewage purification plants in the valley of the Emscher River, a tributary of the Rhine, which drains a portion of the coal-mining district of Central Germany, having a population of about two and one-half million people. Mr. Saville is at work under the direction of Dr. Karl Imhoff, Chief Engineer of the sewerage district named above. Mr. Saville is a graduate of the Massachusetts Institute of Technology, in the course of Sanitary Engineering.

Obituary.

William Henry Lackie, District Manager of the Barber Asphalt Paving Co. for the past six years in New York State and Canada, died at Buffalo, N. Y., Sept. 3, aged 39 years. Mr. Lackie had been employed in past years, before entering the paving business, on the construction of the Baltimore Belt R. R. tunnel at Baltimore, Md., the new Cornell dam at Croton-on-Hudson, N. Y., Trenton Falls dam near Utica, N. Y., the Honduras Ry. in Honduras, Central America, and other construction work.

James R. Shaler, formerly Superintendent of the Panama R. R., died Sept. 7 at his summer home in Ocean City, N. J. Mr. Shaler was born in Pittsburg, Pa., in 1832. During the Civil War he served in the Confederate army. In 1875 he entered railway [illegible] as Superintendent of the Pittsburg, Cincinnati & Louis Ry., at Dennison, Ohio. After five years in [illegible] position, he served a year as Assistant General M[illegible]er of the Louisville & Nashville R. R., at Louisv[illegible] Ky., and then went to Mexico to become Superint[illegible]ent of Construction of the Mexican Central Ry. Re[illegible]ng to the United States in 1884, he entered upon a [illegible]od of eleven years in which he held superintenden[illegible] and managerships with various now extinct rails[illegible] companies in Alabama, Georgia, Ohio, Pennsylv[illegible] and Tennessee. The final year of this period, 18[illegible] found him concluding a service of four years as Sup[illegible]tend-ent of the Chattanooga Union Ry. at Chattanoo[illegible] Tenn. In November of that year, Mr. Shaler was [illegible]inted Superintendent of the Panama R. R. and on [illegible] 11, 1901, he became General Superintendent of [illegible]ame road. He remained in this position until, in F[illegible]uary, 1905, he was appointed Consul for the Rep[illegible]ic of Panama at Chattanooga, Tenn.

Engineering Societies.

COMING MEETINGS.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 21-23. Annual convention at Colorado Springs. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 21-23. Annual convention at Rochester, N. Y. Secy., Willard Kent, Narragansett Pier, R. I.

NATIONAL IRRIGATION CONGRESS.
Sept. 26-30. Annual meeting at Pueblo, Colo. Secy., Arthur Hooker, Pueblo, Colo.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 10-14. Annual convention at Atlantic City, N. J. Secy., H. C. Donecker, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 11-14. Annual convention at Erie, Pa. Secy., A. P. Folwell, 239 West 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 11-13. Annual meeting at Richmond, Va. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 13-15. Annual meeting at Chicago, Ill. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 18-20. Annual convention at Denver, Colo. Secy., C. A. Lichty, Chicago & Northwestern Ry., Chicago, Ill.

AMERICAN GAS INSTITUTE.
Oct. 19-21. Annual meeting at New York City. Secy., A. B. Beadle, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Oct. 21-Nov. 15. Canal Zone meeting. Secy., R. W. Raymond, 29 West 39th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Oct. 24. Annual convention at Baltimore, Md. Secy., P. S. Millar, 29 West 39th St., New York City.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 15. Annual meeting at Washington, D. C. Secy., Wm. H. Connelly, Interstate Commerce Commission, Washington, D. C.

AMERICAN RAILWAY ASSOCIATION.
Nov. 16. Semi-annual meeting at St. Louis, Mo. Secy., W. F. Allen, 24 Park Pl., New York City.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 17-18. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Nov. 17-19. Annual convention at Boston, Mass. Secy., James C. Monaghan, 20 West 44th St., New York City.

OHIO VALLEY WATERWAYS IMPROVEMENT ASSOCIATION.—The annual convention will be held in Cincinnati, Ohio, Sept. 22.

LAKE SUPERIOR MINING INSTITUTE.—The annual meeting held Aug. 24 to 26 included meetings at Ironwood, Mich., Gary, Ind., and Chicago, a special train being provided for the trip. The papers presented included the following: "Underground Steel Construction for Mines and Shafts," by R. B. Woodworth; "A Diamond-Drill Boring on the Mesaba Range," by N. H. Winchell, and "The Detonation of High Explosives," by C. S. Hunter. Officers were elected as follows: President, W. J. Richards, Crystal Falls, Mich., Vice-Presidents, E. D. Brigham, Chicago, Ill., and C. H. Munger, Duluth, Min.; Secretary, A. J. Yungbluth, Ishpeming, Mich.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.—Papers to be presented at the eighth annual convention at Glenwood Springs, Colo., Sept. 21-23 are as follows: "Storage Batteries in Street Railway and Central Station Work," F. A. Warfield, Trinidad, Colo.; "Some Observations on Cultivating Friendly Relations with the Public," J. M. Connelly, Denver, Colo.; "Mazda Street Series Lighting," R. L. Jones, Denver, Colo.; "High and Low Tension Pole Lines," J. C. Lawler, New York City; "The Place of Synchronous Compensators and Induction Generators in Transmission Systems," H. L. Aller, Denver, Colo.; "Creosote Treatment of Our Native Lodge-Pole Pine Poles," Geo. R. Ogier, Norrie, Colo.